TWENTY-SECOND ANNUAL REPORT

OF

The Michigan Academy of Science

PREPARED UNDER THE DIRECTION
OF THE COUNCIL

BY
G. H. COONS,
CHAIRMAN, BOARD OF EDITORS

BY AUTHORITY

LANSING, MICHIGAN
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To Hon. Albert E. Sleeper,

Governor of the State of Michigan

Sir:—I have the honor to submit herewith the XXII Annual Report of the Michigan Academy of Science for publication, in accordance with Section 14 of Act No. 44 of the Public Acts of the Legislature of 1899.

Respectfully,

I. D. Scott,

Secretary.

Ann Arbor, Mich., November, 1920.

Published August, 1921

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G. M. Ehlers, Chairman.

SECTION OF ZOOLOGY

Miss E. P. Butler, Chairman

SECTION OF BOTANY.

R. P. Hibbard, Chairman.

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PROF. E. H. KRAUS, Ann Arbor.

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*Deceased.

TWENTY-FIFTH ANNUAL MEETING

OF THE

MICHIGAN ACADEMY OF SCIENCE

ANN ARBOR, MICHIGAN

March 31 April 2, 1920.

GENERAL PROGRAM.

Wednesday, March 31.

1 30 p m Council meeting, Room Z 231, Natural Science Building. Reports of Committees Nominations for membership

2 30 p m General meeting of the Academy, Room B 207, Natural Science Building Reports of Committees and election of new members

3 30 p m Meeting of Geology and Geography Section, Room M 224, Natural Science Building

8.00 p m Presidential Address, by Professor Edward H Kraus "Recent Progress in Mineralogy, with Special Reference to Crystal Structure" Auditorium, Natural Science Building. The public is cordially invited to this lecture

9 00 p. m Smoker given by the Research Club to the members of the Academy in the University Club rooms, Alumni Building.

Thursday, April 1.

8:30 a m. Council meeting, Room Z 231, Natural Science Building.

9.00 a. m Section meetings as follows: *

Botany—Room B 207, Natural Science Building

Economics—Economics Building.

Geology and Geography—Room M 224, Natural Science Building

Zoology—Room Z 355, Natural Science Building.

12 00 m. Luncheon for the members of the Economics Section, Michigan Union

2 00 p. m Section meetings as follows:

Agriculture—Room G 437, Natural Science Building

Botany—Room B 207, Natural Science Building

Economics—Economics Building.

Psychology—Room B 6, High School

Sanitary and Medical Science—Room 319, Medical Building

Zoology—Room Z 355, Natural Science Building.

8:00 p. m **Symposium**—The Peril of Michigan's Idle Lands. Auditorium, Natural Science Building.

The Situation Carl O Sauer.

The Fire Menace. Filbert Roth

The Cut-over Lands in Relation to Agricultural Use (illustrated). Joseph F. Cox.

The Cut-over Lands and the Need of a Broad Public Policy (illustrated) P S. Lovejoy.

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*The papers presented at the Sectional Meetings are listed under "Papers Presented." page iv

Friday, April 2.

9 00 a m Section meetings as follows

Botany—Room B 207, Natural Science Building

Economics—Economics Building

Psychology—Room P 162, Natural Science Building

Zoology—Room Z 355, Natural Science Building

12 00 m Luncheon for members of the Botany and Zoology Sections, Room 100, Natural Science Building Price, 60 cents

1 30 p m. Council meeting, Room Z 231, Natural Science Building

2:30 p. m General business meeting of the Academy. Auditorium Natural Science Building

Reports Election of officers

Forum on Michigan Land Problems

1 Regarding the need of an inventory of Michigan's land resources by an economic survey

Discussion led by C O Sauer, Manchester

2 Regarding stimulation of use in areas now agriculturally settled, especially by drainage

Discussion led by Dean Shaw, Michigan Agricultural College

3 Regarding the control of fires

Discussion led by George Lusk, Public Domain Commission.

7 45 p m Meeting of the Academy of Science Address by Dean Eugene Davenport, College of Agriculture, University of Illinois, "The New Day in American Agriculture"

TWENTY-FIFTH ANNUAL MEETING

OF THE

MICHIGAN ACADEMY OF SCIENCE

ANN ARBOR, MICHIGAN, MARCH 31--APRIL 2, 1920.

SYMPOSIUM ON MICHIGAN'S IDLE LANDS.

Within the membership of the Michigan Academy of Science there are scientific experts who are engaged in varied lines of research which has to deal directly with Michigan's forestry and land problems. From their work, their acquaintance with the state, and their broad conception of the pressing problem involved in "Michigan's Idle Lands," these men have the viewpoint and the knowledge to state the basic facts underlying the great reforestation and reclamation problem which confronts us and which yearly becomes more imperative in its demand for adequate and effective solution.

Furthermore, they are singularly fitted to advise the proper course for legislative and public commission action, which shall appropriately meet the situation in which the state now finds itself.

At the 25th Annual Meeting of the Academy, held in Ann Arbor March 31 to April 2, 1920, a symposium having for its subject, "Michigan Idle Lands," was held, which in its bearings and recommendations is of vital significance.

In this symposium such leaders of science as Dr. Filbert Roth, Professor of Forestry at the University of Michigan; Prof. J. F. Cox, Professor of Farm Crops, Michigan Agricultural College, Prof. P. S. Lovejoy of the University of Michigan, Dean R. S. Shaw of the Michigan Agricultural College spoke. In the subsequent deliberations, Prof. C. O. Sauer of the University of Michigan as chairman, Mr. John I. Gibson of the Western Michigan Development Bureau, Hon George L. Lusk of the Public Domain Commission, Dr. R. A Smith, State Geologist, Hon. Junius Beal, Regent of the University of Michigan, took active part.

The following resolutions were unanimously adopted:

RESOLUTION ON THE FOREST FIRE MENACE.

1. The prevention and control of wild fire on the cut-over lands of Michigan is the most urgent item in any plan for the development of these lands, and irrespective of whether they are to be utilized for farming, grazing, forests, or recreation.

2. The fires have caused and are causing enormous damage. They take human life. They destroy improvements and manufactured forest products. They destroy forests and prevent tho natural reproduction of forest growth. They damage the soil by burning out its organic constituents and by exposing it to the wasting of wind and water action. They destroy game animals and birds and remove the cover which alone can furnish safe and

suitable breeding grounds. They destroy the native beauty of the region, leaving only waste and desolation, unattractive for recreation purposes.

3. It is perfectly practicable to prevent and control wild fire to a degree which will make fire losses negligible. The costs of such prevention and control are justified on any one of the items of damage alone.

4. The Public Domain Commission is directly responsible under the statutes for the enforcement of the fire laws. It is the duty of the Public Domain Commission to take such action as lies within its power, looking toward the control of fires upon the lands of the state.

5. The Public Domain Commission is urgently requested to secure a full enforcement of the existing fire laws, to investigate, determine and report, to the people of the state and the legislature, in full and unequivocal manner, as to the damage done by fire, and as to the appropriations, modifications of existing laws, organization or other items required, in order to secure for the lands of the state prompt and adequate fire protection.

Resolution on the Reclamation of Michigan's Non-Productive Area.

The following procedure is deemed the proper course of action for the reclamation of Michigan's non-productive area:

1. That an inventory be made of the land resources of Michigan by counties. This inventory should constitute a series of county reports, accompanied by maps, along the following lines:

   (*a*) Nature of physical conditions

   (*b*) Present economic conditions, together with the record of past and present experiences in the use of the area.

   (*c*) A classification of the land according to its highest indicated use

2. That in the study of physical conditions of the land (*a*) first and chief attention be given to soil conditions, with a classification of soils which will recognize their genesis and which will give maximum emphasis to their distinguishing qualities. (*b*) that climate be adequately considered as a factor in utilization; and (*c*) that topography, drainage, location, and the size of areas of unit characteristics be separately recognized and considered as factors affecting possible use.

3. That an intensive study in land economics be made for each area on the manner of present utilization of the land and the history of its use. In connection with this study there should be determined (*a*) extent of idleness of the land, (*b*) the different types of use to which land is now being put, and (*c*) the returns from the several uses and the place of these uses in an economy of the area.

4. That the land of Michigan shall be classified into a series of classes on the basis of return, or anticipated return, ranging from land suited to highest grade and most permanent agriculture through grazing and forest land to permanent waste land.

5. That the work of this survey be carried out with the fullest utilization of the scientific personnel in the State and in consultation, and if feasible, in cooperation, with the proper federal agencies.

6. That the committee succeeding the present committee of the Michigan Academy of Science be charged in particular with inquiring into the

most desirable soil classification, of analysis of existing land use, and of land classification.

To this end the following action is recommended to the State Legislature:

1. That the law providing for the Soil and Economic Survey be made operative.

2. That the law be amended by providing for a Board of Control, consisting of the Secretary of the Public Domain Commission, a professional expert in agronomy, a professional expert in soils, a professional expert in forestry, a professional expert in land economics, and an additional representative from the northern and one from the southern peninsula

3. That the initiation of county studies be adequately safeguarded by prior experimental application of the principles on which the survey is to be executed.

THE NEED FOR A POLICY FOR THE CUT-OVER LANDS OF MICHIGAN.

BY P. S. LOVEJOY.

Concerning many public questions Michigan has a well-defined policy. We have a good road policy, a policy as to education, as to the sale of securities, for instance. But we have no policy as respects our idle stump lands—nothing more than fragments and odds and ends of policy and procedure.

Over a third of this state in non-productive, idle land and the gross area of idle land is increasing instead of decreasing. Great areas of the idle lands are depreciating in quality. These great and growing tracts of idle and depreciating lands are a liability instead of an asset to the state, and a liability which constantly becomes greater.

Over a third of Michigan is virtually bankrupt, is paying hardly more in taxes than the cost of collecting the taxes, is unable to provide itself with tolerable roads and schools, is unable even to furnish itself with police protection.

Over a third of Michigan is idle and non-productive not wholly because the soil is poor, for some of the soil is excellent; not wholly because the climate is inhospitable, for over great areas the climate is excellent; not because the lumbermen cut the old virgin forests, for they were ripe for harvest; not for lack of some manner of effort to develop the country, for there has been constant effort. These lands are idle and worse primarily because of fire, fires, repeated burning over. The fires have come year after year; they have burned and reburned over millions and millions of acres, they have killed old timber and young timber and the seed in the ground; they have destroyed the organic materials on and in the soil, the improvements of settlers, villages and towns; they have taken hundreds of lives. These things are matters of public record and general knowledge: so constant in their recurrence that they have become matters of course, like rain or frost or sickness. For generations we have had laws and more laws concerning fires upon the statute books. For decades we have had officers charged with fire prevention and suppression. But the fires have not been controlled and the state still lacks anything like a clean-cut policy as to the fires of the stump-country.

As to fish and game the state has a policy, of a sort. There is unanimous agreement that the game supply is dependent more upon the cover than upon the enforcement of restrictive legislation. But the presence of cover is determined by fire and, over great areas, the fires have practically exterminated the game birds and animals .Upon our statutes fire control is made subordinate to the game and fish business. If this is a matter of policy it requires radical revision. The game will increase if the fires are stopped—cannot be maintained if the fires continue.

We have a new policy as to State Parks. We desire the development of the north country in connection with tourist traffic. But millions of

acres of the state's north country is black and desolate and dreary with the devastation of fires. Summer visitors are apt to prefer a safe and green country. If our summer resort business is to develop the fires must be stopped.

For thirty years the greatest exporter of the best lumber the world ever had, today Michigan imports more timber than it grows, and grows no timber save by accident. In a decade timber consumption will exceed the timber cut by 50%. The annual freight bill on imported forest products totals a sum great enough to plant half a million acres to new forests. Trainloads of timber are coming into Michigan from Arkansas, from Oregon and Idaho. With over ten million acres splendidly suited to the production of pulping species, our publishers are paying five and ten cents a pound for newsprint. The lumber for a ready-cut, one-story, five-room frame house, which was listed at $883 in 1915, is now quoted at $3,272. There is a world-wide shortage in high-grade timber. In the face of all these things Michigan still lacks a policy.

Our statutes require that not less than 600,000 acres of State Forest be maintained. For years the State Forests have received reasonably good fire protection—enough to demonstrate the perfect feasibility of protecting forest lands from fire: but the State Forests are the remnants of tax-delinquent and bankrupted lands which have finally dribbled into state ownership; they are cut-over, skinned and burned lands, for the most part "forests" by courtesy only. Planting operations have been carried on upon the State Forests with marked success and with a low cost hardly to be duplicated in America, but, at the present rate of planting, some 60 years will be required to put the state's present 600,000 acres to work—and near fifteen million acres are idle and non-productive. The existing State Forest policy is but a fragment and wholly inadequate to meet the situation. Nobody has ever maintained that it was adequate.

Great aggregates of our idle lands have soil of high agricultural value, but the areas with good soil and location lie mixed and scattered through still greater areas of low-grade sand and swamp and rock areas. Attempts to develop the agricultural possibilities have not been lacking. Too often such attempts have been mere exploitation of hopeless sands and too hopeful settlers, and this situation has so long prevailed that the state has suffered enormously in reputation and in the sale value of its good and improved lands. The scandals of the sand-land exploitations yet continue. Great areas of good land lie idle, often held off the market for speculation.

Nearly a sixth of Michigan is owned by 32 concerns A single firm owns a million and a half acres of Michigan. This system of ownership has been possible because of our system of taxation. Should the state decide that land monopoly in this degree is not desirable, and should it take steps to terminate such monopoly, that would involve a matter of policy where today there is none.

It is certainly in the interest of the state that the maximum possible acreage become permanently productive and profitably at work. Our fifteen million acres of idle lands can be put to profitable work in but few ways. A portion of them are suitable for agriculture, another portion is suitable for grazing. A still greater portion is suitable for neither farming or grazing in any form. This great fraction, millions upon millions of acres, is

suitable for forest production and with it, game and fish and fur production. With the presence of forests and their game and fur and fish, an enormous industry in tourist traffic is assured. The question then is. Do we want these idle lands of Michigan put to permanent and profitable work? If so, how may that be contrived?

Such situations are often met in the business world, as in the case of other forms of bankruptcy. How does the business world proceed in such cases?

The first thing is to take stock of the resources—to make an inventory. Michigan needs an inventory of its idle lands. That will be a soil-survey plus an economic-survey which shall consider and appraise the properties at their true value. A law providing for such work is today upon our books. It is inoperative. To bring that law to life and put it into execution will require a policy.

The items required of an adequate land policy in Michigan are not new or untested. Wisconsin has a soil-survey. California has in operation a modern plan for settling idle lands. The Governor of Kansas has proposed a scheme for the eradication of the land-hog. Nebraska protects her citizens against the land-shark. Pennsylvania has millions of acres in her State Forests Nothing new or untried in the way of policy or plan is required by Michigan. In practically every item Michigan has already made tentative experiments. But we move too slowly and the situation becomes acute, for we have ten or fifteen million acres of idle lands and the area increases.

To remedy these things nothing can suffice save a real policy soon put into effect. It needs to be a real policy and a workable policy and a policy upon which the state can unite to the end that every acre of the state may be working steadily and profitably all the time.

As to the basic facts no question is raised As to the ends desired there is agreement. As to the means to those ends there should be discussion, but it should soon terminate in specific and adequate action. The legislature has never tackled these problems as a group and save by handling them as a group they cannot be worked out. In the face of the bankruptcy of over a third of the state the legislature has failed us. With all these things crying for attention the University has remained aloof and superior; the Agricultural College busily content with its own problems, the commercial organizations of the state have not even recognized that the prosperity of the state is in grave jeopardy.

To open this subject and follow it through to solution will require vision and technical skill and patience and work. If those qualities are to be found in the Michigan Academy of Science, it has such an opportunity and such a duty as seldom presents itself to any group of men.

UNIVERSITY OF MICHIGAN.

THE EFFECT OF FOREST FIRES UPON THE SOIL OF THE NORTH LAKE STATES

BY P. S. LOVEJOY.

Question having arisen as to the character and appraisal of the damages done by forest fires, inquiry as to the effect of fires upon the soils burned over was addressed to the U. S. Bureau of Soils, reply (dated Nov. 13, 1919) being received from the Chief of the Bureau reading in part as follows:

". . . With the exception of one or two determinations for calcium carbonate and four or five for organic matter, we have made no chemical analyses of soil samples in connection with our soil survey work in Northern Michigan, Wisconsin and Minnesota . . . As to whether or not the Bureau of Soils is able to place any value upon so-called "humus" in soils, I have to say that so far we have not studied this question sufficiently to be able to assign such value to organic matter either in cumulose deposits like muck or peat or to the organic matter present in normal timbered or prairie upland soils. . . ."

Another inquiry of similar character was sent the Bureau of Soils at about the same time by J. A. Doelle, Secretary of the Upper Peninsula Development Bureau, reply (dated Nov. 2, 1919) being received from Dr. C. F. Marbut, in charge of the soil survey work of the Bureau. This reply reads in part:

". . . No reliable information on the subject (injury to soils caused by uncontrolled woods' fires) has ever been obtained . . . It is impossible, therefore, to give an affirmative or negative answer to the question. In a general way the humus that is of value to a soil is in the soil and not on it. The organic matter that is burned by forest fires, or by prairie fires, is on the soil and not in it. For that reason it seems probable that the injury done to the soil by forest fires is not as great as is often supposed . . ."

Dr. Marbut's letter having been referred to me by Mr. Doelle, reply was made to the following effect: Specific data and centuries of careful observation are not wanting and definite answer to this question is available. Professor Snyder (1) records a loss from the soil of 2,500 pounds of nitrogen per acre as a result of the Hinckley, Minnesota, fire, the humus content of the soil being 1.69% before the fire and only 0.41% after the fire.

This analysis is quoted with approval by Mosier and Gustafason (2) who add further evidence as to the soil injuries associated with the depletion, by fire and otherwise, of the organic contents of agricultural soils. There is a mass of similar data and conclusions.

This statement having been forwarded to Dr. Marbut, he replied (Dec. 2, 1919) in part as follows:

"I note the quotations (from Snyder, Mosier and Gustafason) and desire to say that the difference between us lies wholly on the question of

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humus. The leaves and moss lying on the surface of the ground in forested regions of the northern part of the United States is not humus . . . I think it probable that the (Snyder) analysis showed a content of organic matter on top of the soil of 1.69% before the fire and after the fire it showed a content of 0.41% . . . I think it probable that a further discussion of the matter is not profitable because no exact value has ever been placed on this layer of leaves and moss . . . Until some value is placed on it, it is hardly worth while to discuss the matter . . . The question can only be determined by experiment . . . It is extremely probable that the prairies were burned every year . . . (but) the fires did not preclude the prairies from accumulating humus. Would it be right, then, to conclude that the fires prevent the accumulation of humus in forests? . . . I must again insist upon the statement . . . that 'injury done the soil by forest fires is not as great as is often supposed.'"

The statements of Professors Snyder and Mosier thus being challenged, the matter was referred to them. Professor Snyder replies (Dec. 19, 1919) that the Hinckley analyses were made quite in accord with the technique of the Association of Official Agricultural Chemists, and that leaves and moss were not included in the samples He further remarks that: "A fire confined to the surface of the soil, as a mild prairie fire, is entirely different in its action to an intense forest fire where iron rails are warped and twisted, and the combustion is not confined alone to the surface accumulations . . ." And again: "I consider that the permanent crop-producing capacity of many of our burned-over forest soils . . . has been appreciably lowered, because of forest fires which could have been prevented. . . ."

Professor Snyder cites further references to his published work, from one of which I quote: (3) "Soils covered with pine, in which sand largely predominates, frequently lose one-half to three-fourths of their total nitrogen when visited by forest fires. The sand being of open and porous nature aids in the complete combustion of the humus. In the timbered region of the Northwest, the great fires of 1894 resulted in the average destruction of over 1,500 pounds of humus nitrogen per acre, to say nothing of the nitrogen lost in the burning of the timber . . . The prairie fires have not been so destructive upon the humus as the forest fires because the burning has been confined more to the surface. An average prairie fire, however, will remove more nitrogen from the soil than five ordinary crops of wheat."

Professor Mosier writes (Dec. 12, 1919) in part as follows: "There is no question at all in my mind that the burning of a forest will destroy a great deal of very valuable organic matter that lies on the surface and which, upon clearing, could easily be incorporated with the soil when plowing is done . . . The sand dunes in part of Illinois are covered with black-jack oak, and where the fires have taken place the sand to the very surface is yellow with almost no organic matter, while in other parts where no fires have occurred there is not only a surface of leaf mould an inch or two in thickness, but the surface two inches of sand is quite dark with humus . . .

"It would be my estimate that where fires have not occurred in foresta for a great many years (as described for the Lake States) there would be on the surface and in the surface two inches of soil . . . from 100 to 125

tons of organic matter . . . Supposing that we assume that this contains 16 pounds of nitrogen per ton, which is probably too low, then in 100 tons there would be 1,600 pounds of nitrogen, which, at present price, would be worth $480 per acre . . . not to say anything of the value of the organic matter in the physical improvement of the soil. I sometimes estimate . . . (this) as worth about one-fourth that of the nitrogen . . . If we consider the large areas that burn over, the losses would simply be incalculable. . . . 'There is considerable difficulty in supplying or restoring the organic matter to the soil, especially in northern latitudes Even if two tons of clover could be grown and all this turned under, it would take six years to restore the nitrogen . . . In general the upland timber soils of the Lake States are in need of organic matter . . . There is no question but that the leaf mould and the organic debris that is accumulated on the surface and in the surface few inches of soil is of immense value to the agriculture that is to be practiced there . . . The minimum value that would be placed upon this material will be much higher than the cost of replacing a sufficient amount to produce good crops."

The comments from Professors Snyder and Mosier having been briefed and forwarded, Dr. Marbut replies (Jan 17, 1920) at some length. I abstract this reply in part as follows·

"Samples have recently been collected from an area which was severely burned by a forest fire. A sample was also taken from an average spot in an adjacent unburned area. It may not be stated when or where the samples were collected, for the results have not yet been officially published. The results of the analysis of these samples may not settle the matter but are worth as much as any other data of the same kind and quantity. The samples from the burned area show an organic content averaging about 3.5%, while the (one) sample from the unburned area had a little less than 3% of organic matter. Certainly no burning of the organic matter took place in this soil. A large proportion of the burned area, after the fire, still had a covering of unburned organic matter ranging up to nearly an inch in thickness. As to the comparison between prairie and forest fires it is only necessary to refer to the analyses just quoted The prairie fire could not well be confined more to the surface than this case indicates is true for forest fires. In severe forest fires the leaf mould is not always removed, and, if these results are applicable generally, it is rarely removed. A prairie fire could not well remove more nitrogen from the soil than five ordinary wheat crops, for the humus removed by a prairie fire is not *in* the soil at all.

"The analysis quoted above fully answers Professor Mosier's statement, and his figuring, which seems to be correct, is based upon an assumption which is wrong. The material burned is not part of the soil when burned."

Dr. Marbut concludes: "On the basis of the *supposed injury*, as stated by Professors Snyder and Mosier, when compared with my own figures showing no loss of soil organic matter at all, I *still* feel justified in repeating . . . that 'it seems probable that the injury done to the soil by forest fires is not as great as is often supposed.'"

There follows a set of quotations and interpolated comment which I reproduce verbatim.

"I desire to quote some opinions myself: 'The quality of the humus present (in forests) is in inverse proportion to its quantity.' (Grebes, Boden-

kunde, 3rd Edition, p. 176, quoted by Ramann, Bodenkunde, 3rd Edition p 170.)

"'In general a high humus content in forest soils is no evidence of any special soil fertility (quality), it is, however (such an evidence), if the humus is uniformly mixed (incorporated) with the soil; one can then, as a rule infer that other things being equal, the soil with the higher humus content is the richer On the other hand, however, the *presence of a compact layer of humus* (decaying or partially decayed plant debris) *overlying the soil is to be considered as an evidence of soil degeneration'* (ruckgang). Ramann, Bodenkunde, 3rd Edition, p. 170.

"The layer of humus burned by forest fires in northern forests is in many if not most cases exactly what is described here."

"'The physical changes which take place in a soil when covered with rohhumus (the layer of leaf mould, etc., lying on the surface in northern forests) takes place along with the chemical changes. *Through the removal of the soluble salts one of the most important conditions for the formation of crumb structure is removed.* The crumbs (previously formed) are destroyed and the soil grains become *packed close together.* Comparative investigations show a progressive decrease in volume of (soil) pores and also of the air space in the soil. All heath soils show almost a minimum of aeration. Often the top layer of the mineral soil is so compact that, when made up of sand, it breaks up in flakes

"'A further unfavorable action lies in the annihilation, or at least a *very important reduction of the animal life. Earthworms disappear rapidly as the soil becomes covered with a layer of organic matter* (rohhumus). The acid reaction of the soil *decreases the bacterial content of the soil and this decreases the rate of decomposition of the organic matter.* On the basis of these conditions it is evident that once the accumulation of a covering of forest debris has begun it proceeds rapidly, since an important cause of the destruction of the forest debris is decreased.'

"'While the mixing of "sound" humus (with the soil) and the covering of the surface with a layer of *loose and open* forest debris is of great importance for forest soils, the existence of a *thick layer* of forest debris is *unfavorable both to the soil and to the forest.* If such material accumulates to considerable thickness it assumes the character finally of a typical humus soil which, in many cases, constitutes a starting point for the formation of a "hochmoor" (peat soil).' Ramann, Bodenkunde, 3rd Edition, p. 207.

"Under *changes effected in the soil under* (a layer of) *rohhumus*, Ramann, Bodenkunde, 3rd Edition, p. 199, states:

"'With progressive leaching, the upper horizon of the soil becomes *poor in soluble material.* The leaching is hastened by the compactness of the soil (because of the layer of surface organic matter) and the action of the humus colloids, the latter effecting the removal from the surface of iron and aluminum.

"'If "rohhumus" covers the soil, a humus "sole" is formed which hastens the leaching and in a relatively short time the surface horizon of the soil is *exhausted of its soluble material* and there is thereby developed a gray horizon low in humus' (and mineral matter also)."

"On the succeeding page, at top, he shows how hardpan is formed through the continued action of the same process.

"On page 550 he states that 'for forest trees, or at least for most of the species, the content of the mineral plant food in the soil is less important than a good physical condition.' Anything that acts on physical character unfavorably is an injury therefore. It is stated above in another quotation from Ramann that a *thick cover of organic matter on forest soils acts unfavorably on their physical character*

"The figures cited in this letter show that Professor Snyder's analyses do not have universal applicability My observations show the 'humus' layer not to have been completely burned and, therefore, there was no burning of humus out of the soil. I disagree wholly with the statement that a prairie fire removes as much nitrogen *from the soils as* five ordinary wheat crops.

"Professor Mosier's figuring seems to be correct, but the assumption on which it is based is wrong.

"The position Professor Lovejoy tries to maintain by means of these quotations in not tenable therefore

"The quotations from Ramann show clearly that according to the studies made by German specialists, *the accumulation of a thick layer of forest debris, such as that which accumulates in the forests of the Lake Region, is injurious not only to the soil, but to the forest.* Anything that can prevent such accumulation will not only injure the soil, but will benefit it."

Thus Dr. Marbut, in charge of the soil survey work of the U S Bureau of Soils, arrives at the conclusion that, so far as the soil is concerned, uncontrolled and miscellaneous forest fire is beneficial

The question would now seem to be as to the weight to be given the Ramann quotations. For this purpose the correspondence was placed in the hands of Professors Sauer (Geology) and Roth (Forestry) with the request that they pass judgment upon the technical matters involved

Dr. Sauer's memorandum is as follows

"A consideration of Ramann's 'Bodenkunde' does not indicate that the author believes humus accumulation in the latitude of the Great Lakes on uplands of loam, silt or clay, to have harmful influence in forest areas. The direct implication of pages 170 ff. (3rd Edition) is quite the contrary. His general attitude is expressed in the statement: 'One can assume as a rule that under the same conditions the soil that is more richly supplied with humus is also more productive. In contrast to this condition is the occurrence of compact layers of humus materials that are superimposed on the mineral soil as a sealed cover.' On page 171 he refers to the latter condition as a firm, fibrous, acid layer that may be cut (schneidbar), later elaborated under the terms 'rohhumus' and 'trockentorf' (p. 193 ff). The causes of such formation are stated as (1) very poor soils by reason of lack of plant food; (2) exclusion of air, especially by submergence; (3) excess of water, commonly combined with low temperatures; (4) low temperatures of very high latitudes; (5) aridity, especially in the warm season. Further statements indicate that these conditions are applicable especially to poor sands with orstein formation; ill-drained surfaces; heaths and highland

moors; tundras and regions or aridity. In forests the condition is characterized by compact and excessive accumulations of forest litter (streudecke).

"These conditions are not characteristic of the Great Lakes except for normal bogs and, possibly, exceedingly local upland moors. They are most certainly not the conditions of lands of agricultural possibilities, nor of the bulk of the pineries of the Lake States. Moreover, the forest conditions of the higher European latitudes with which the observations of Ramann are mainly concerned, possessing lower summer temperatures and lower evaporation, cannot be transferred by inference to the Great Lakes region. The type of soil produced by rohhumus accumulation is podsol, or podsol-like (see especially Ramann, 'Bodenbildung und Bodeneinteilung,' 1918) and its American equivalents, if found, will be in higher latitudes than those of the Great Lakes."

Professor Roth's memorandum is as follows:

"Ramann is perfectly correct. He is writing a text on forest soils, and the Marbut quotations refer to a certain well-known forest soil type.

"But there is not one square rod of Michigan hardwood and hemlock where this (soil degeneration as indicated by podsol) applies. There is not a square rod of 'hochmoor' in the state. There is nothing of the sort in our normal pineries.

"'The layer of leaf mould under our Lake State forests is rohhumus!' We have the finest leaf mould in the world under our Michigan timber. This typical north woods mulch has kept our soils in the finest fettle for untold centuries, fine, friable, continually getting better with the forests they carry—up to the coming of the fires.

"To compare our conditions with those of the Luneberge heath and of Labrador and Archangel is completely unwarranted. To figure it out that fire, by preventing 'such an accumulation' will 'not only not injure the soil, but will benefit it,' is entirely fallacious"

If it may now be conceded that the Ramann references are largely irrelevant, it remains to comment upon the technique of Dr. Marbut's investigations and upon the legitimacy of the conclusions at which he arrives.

It will be noted that soil samples (number, location, condition and by whom not specified on account of departmental regulations) from a "severely burned" area are reported to show an average organic content of about 3.5%, and that the single check sample from an adjacent unburned area analyses a little less than 3% in organic matter. From these results it is announced that "certainly no burning of organic matter took place in this soil." But something did burn: what, in what quantity and where, is information also lacking.

According to the record, the soil from the burned area had a higher organic content that that from the unburned area. Aside from the fact that but a single sample was taken from the unburned area, and that there is nothing to demonstrate that this sample represents a true average, and aside from the fact that the fire left a covering of unburned organic material up to nearly an inch in thickness, thus demonstrating that the fire was not really severe, as such fires go, so far as the reported results indicate, it would be logical to assume that the fire increased the organic content of the soil by about 0.5%. Perhaps another fire, consuming the balance of the organic material left by the first fire, might increase the organic content

of the soil to 4 or 5%, and repeated fires might still further add to the combustible ingredients of the soil.

It would be interesting to learn whether the laboratory technique used in these investigations was such as to distinguish between humous materials and charcoal. Much of the dark material in the surface of our Lake States soils may well be charcoal, but the plant food value of charcoal is not apt to be high.

As to the question of the severity of the fire the circumstances related are adequate. Professor Roth mentions heat enough to melt sand. Professor Snyder speaks of heat enough to warp iron rails. I have seen rock slopes where the surface ran into slag, all from forest fires. But fires of such severity are indeed as rare as those which increase the organic constituents of soils by burning them up.

It is true, however, that under average Lake States conditions, the first fire over virgin formation does not, as a rule, consume the entire organic layer of the forest floor. But, under Lake State conditions, the first fire is to succeeding fires as a comber on a beach is to succeeding combers, and if Dr. Marbut does not know this, or choose to concede it, other and competent observers have made record of the circumstances, as will be shown.

Between the humus of prairie soils and that of forest soils there is no legitimate comparison in this connection. While fires on the prairies were common enough they were not annual affairs and no one who has had experience with both prairie and forest fires would presume to compare their relative severity. Moreover, in the nature of the case, where prairie soils obtained the bulk of their humus from the decomposition of roots, the forests, with their heavy and continuous shade, their higher humidity, their soft and heavy mulch and radically different root system, obtain the bulk of their humus from the decomposition, not of roots but of the layer of fallen leaves, twigs and logs which makes up the forest floor. If very full and competent confirmation of this point is required it is not lacking, as will be shown.

Under Lake States conditions, the fires recur, forest and brush and "plains" fires, year after year, each in turn removing most of the current accumulations of organic material and yet more of the ancient accumulations laid down by the virgin forest. Each fire anew exposes more of the mineral soil with its remaining organic material to the action of direct light, rapid evaporation, frost and wind action, and to slope-wash, these in turn wasting away whatever the fires may have left of the original organic material and decimating the living things associated with fertile soils.

If the narrow terminology of the soil technologist is to be justified in insistence upon the fact that the bulk of the organic material of the forest floor is *on* the soil and not *in* it, such insistence is, nevertheless, futile. The roof of a house is not *in* the house but may not, therefore, be burned without affecting the value and usefulness of the house. If humus, in the strict sense, is a valuable ingredient of forest soils, and if the humus of forest soils originates in large part from the progressive decomposition of the fallen forest litter which makes the forest floor, then the destruction of the litter *on* the soil must operate to prevent the development of humus *in* the soil. This is, of course, the case, and, all chemical determinations notwithstanding, it must be insisted that forest litter burned on the soil can

never, under any circumstances whatsoever, become humus in the soil, on the soil, or otherwise available to plants, soil or man. It is this consideration and understanding on the part of Professors Snyder and Mosier to which Dr. Marbut objects as being merely an "assumption" and a "supposed injury."

Professor Fernow remarks (4) "that from fire a damage even greater than the loss of the crop is experienced in the loss of the soil cover, the litter and duff, which is the forest's manure. . . Even the soil itself, often formed only by the mould from the decay of leaves and litter accumulated through centuries, is destroyed, and thus not only the practicability but the possibility of forest restoration is frustrated. . . The yearly conflagrations destroy . . . standing timber, they kill the young growth and destroy even the soil, the fertility, an accumulation of centuries of decayed leaf mould."

In his classic text on soils, Dr Hilgard (5) remarks, in passing and as too obvious to warrant detailed discussion, that: "Forest soils are usually dark tinted for some inches near the surface, owing to the presence of leaf mould," that "in forests of humid climates . . . not only does the autumnal leaf fall, as well as decaying twigs and trunks, become obviously incorporated with the surface soil as decay progresses, but active animal agencies carry the organic remnants bodily down." He remarks upon "the uniformity, lack of structure and loose texture of the surface soil, especially of forests" and that "meadows and woodlands generally show the highest humus content in their surface soils, gradually increasing (the humus) while in that condition"

Van Hise (6), in discussing the effect of forest fires, states that: "Another serious result . . . is in the deterioration of the soil. The fires do not simply confine themselves to the timber, but they burn the humus in the soil itself Frequently . . and especially if the fires run over the same area several times, there is left but little or no organic material. In this case must again begin the slow process of accumulating a sufficient amount of organic material in the soil before a good growth . . can be secured."

If European references of specific applicability are necessary, perhaps Professor Schlich (7) may be a competent witness. "The burning of the dead leaves and litter on the ground prevents the accumulation of humus and the improvement of the soil and renders the soil poor and hard" Further, speaking of the European practice of raking out the forest litter for sale as compost material, he says. "Only places with fertile, deep and fresh soil can bear a limited removal of litter" And, "Among the worst instances of damage to the soil by the removal of litter are the State Forests near Nuremberg, where even Scotch pine . . . can now only grow as a dwarfed scrubby tree almost useless unless for fuel"

"It is the duty of the State to impart public instruction as to the extreme impoverishment of forest soil by the constant removal of litter," says this authority in concluding a chapter on "Forest Protection." In more ways than one it would appear obvious that European conditions may set no precedents for American procedure, for Dr. Marbut of the U. S. Bureau of Soils advocates the use of fire as a measure for soil improvement, and quotes German authority in alleged approval.

Endless references of equal standing and import might be quoted, all, so far as discovered, further substantiating the fact that fire may be expected to damage the soil over which it runs, but the question is not merely as to the effect of fire on soil; it is as to the effect of fire upon Lake State soils. Of the Lake State soils there are three main classes, the clays and loams, the sands, and the mucks and peats, each respectively the typical sites for hardwood-hemlock, pine, and cedar-tamarack forests.

As to the effect of fire upon these soils, Dr Marbut first states that: "No reliable information has ever been obtained" To this contention the following citations seem opposed, as typical of many more which are available.

Leverett says of Minnesota· (8) "Large areas have been swept by forest fires, and these fires have destroyed much of the accumulated leaf mould. . . . The principal damage by fire in this State, both past and prospective, seems to be the destruction of peat in the bogs. In such cases there is not only the loss of a valuable fuel, but the land is left in rough state, ill-suited to cultivation" This is surely a mild statement as to the effect of wild fire upon cumulose soils which may run 90% organic and combustible in like degree. That controlled fire may be used to advantage in the muck areas, under certain circumstances, is, of course, beside the question. As a matter of fact, great aggregates of peat and muck soils have been utterly devastated in each of the three Lake States and within very recent years. The item would seem tó be undebatable.

As to the sandy soils, competent evidence is also ample. The United States Department of Agriculture—if evidence from this source is to be credited under the present circumstances—in discussing the possibilities of farming the lighter Lake States sands, states: (9) "The successful handling of the jack-pine plains begin with the clearing of the land The logs, stumps and brush must be cleared away, but nothing should be burned off that can be plowed under for humus. The great need of the soil is for humus. . . . Rotted logs should be picked to pieces and scattered thinly over the ground. All sweet ferns, huckleberry bushes, brakes and other small growth should be plowed under and not burned off

"Burning over the soil not only depletes it of its humus content, but tends to make it sterile and dead. . . . A fierce fire left to run over the land in clearing will destroy most of the beneficial organisms, leaving the soil inert and unresponsive, like freshly turned subsoil. . . .

"The land has been repeatedly burned over every few years, for nobody knows how many generations; hence, there is little humus or vegetable matter in it. It lacks nitrogen It is likely to be a little leachy It is likely to suffer severely in time of drought It needs protection from the winds."

Says a Wisconsin bulletin· (10) "Originally nature, through a forest . covering, protected these loose sands against severe winds Man removed the forest covering . . . and later . . . the organic matter which bound these soils together . . . until many acres are left to the mercy of the winds. . . . Farmers who live in the sandy soil region agree that each spring's sandstorm is worse than preceding ones."

Referring to Michigan conditions, Leverett says: (11) "The extensive areas of pine plains . . . furnish a problem as to methods of manage-

ment . . . and especially since parts of them have been devastated by fires."

"Forest fires have frequently swept the cut-over lands," says a Wisconsin authority (12), "adding to the desolateness of the country. . . . There are areas which have been burnt over repeatedly, leaving little of the rich vegetable matter in the soil. . . . Where forest fires have burnt over the ground so completely, considerable difficulty may be experienced . . . in getting a (new) growth started."

So much for the mucks and the sands. As to the loams and the clays the situation is identical save in that, being originally of higher quality, these soils are not injured by fire in so radical and obvious a way as are the open textured mucks and sands.

Concerning a typical group of silt-loam soils Whitson and Gieb says: (13) "Compared with prairie soils which have shown lasting fertility, these soils are distinctly low in organic matter and nitrogen. In fact, most upland soils of wooded regions are low in organic matter. However, the vegetable matter which they do contain when first cleared and broken is of an active character, but provision must be made for maintaining and increasing this material."

As to sandy loams, which make up the bulk of the Lake State loams, it is reported: (14) "The organic matter of these soils is also low. . . . This organic matter is largely in the form of leaf mould and fine roots, and hence is of an active character . . . furnishing sufficient nitrogen for a few years. It is, however, exhausted with readiness (by farming) and the most important point in the management of such lands . . . is to increase the organic matter"

With the clay soils the situation remains the same with the further consideration that they are more subject to slope-wash and erosion when once stripped of the forest cover and mulch.

In speaking of the heavy soils the Wisconsin authorities say: (15) "On many of the steeper slopes erosion will be a problem requiring attention. . . . Small ravines soon form if the surface of the ground is not covered . . . These gullies enlarge quite rapidly unless checked."

The relation between forests and erosion has been studied in vast detail, and in many countries the results of such studies being in remarkable accord and especially with respect to the relation between forest fires and the resultant washing and wasting of the soil.

Dana remarks (16) that: "From the standpoint of erosion, every fire on hilly land is a menace—the steeper the slope the greater the menace. Conflagrations which completely destroy the cover are, of course, most dangerous, but even light surface fires are not to be disregarded

"By destroying the humus . . . these light fires tend to harden the soil and to reduce materially its absorptive capacity. Repeated fires on the same area are particularly dangerous, since they open the stand, remove all trace of vegetable matter, and may cause the soil to harden and pack so as to be almost impervious" (thus increasing the rate of run-off).

No mention has yet been made of the type of country where the surface is rough and the country rock lies close to the surface with the mineral soil thin and patchy, or of the broken boulder fields typical of a considerable area of the north Lake States. In spite of their unfavorable condition these

areas orginally supported a very fair hardwood forest. With the advent of fire to such lands, and the rapid destruction of the organic accumulations, wash is often immediate and rapid, and easily results in the total and practically permanent devastation of the area. Leverett remarks upon the situation in Minnesota (17) and the Canadian reports show enormous areas to have suffered terribly from this form of fire and soil damage. (18) But perhaps it will be argued that this is not a soil damage, properly speaking, insomuch as the soil has merely been moved about, thereby suffering no material change in its ability to go through a set of sieves or in its test-tube reactions. Millions of acres of once productive country have, nevertheless, been rendered permanently useless to man on this account

It is to be presumed that no particular demonstration will be required as to the ubiquity and recurrence of fires throughout the north Lake States, but, if wanted, the State Forester's and Fire Warden's reports are available and the region itself is an open book of fire writings.

Only an insignificant proportion of the whole region has been free from fire during the last fifty years; the bulk of the lands have been fired repeatedly; millions of acres have been burned over time and again during the last decade.

The fires have run and do run and no class of soil or type of country has been free from them. Of the many and tremendous forms of damage done by the fires, damage to the soil is but one, and, perhaps, not the most important. But it is important and vastly more important for the future than it has been in the past Before long all those thirty of forty million acres of idle land, now lying fire-swept and non-productive in the north Lake States, must be returned to productiveness Whether these lands can be most profitably devoted to agriculture, grazing, or forest, whatever they may be able to produce will depend primarily upon the quality of their soil. By whatever fractions these soils are reduced in fertility, in their ability to produce useful products, by that much the past depreciates the labors and the investments of the future The total of the depreciation in soil productivity and availability, caused by fire, will place a heavy burden upon many years.

But we may take heart for perhaps the situation is otherwise On November 2, 1919, the official in charge of the U S. Soil Survey certified that "no reliable information has ever been obtained" as to the effect of fire upon our soils Subsequently, having found no occasion to give consideration to the work or opinions of Professors Snyder and Mosier, Dr. Marbut has consulted a German text and has conducted certain analyses of soil specimens from a "severely burned" area, these being checked by one sample from an adjacent unburned area. (Location, numbers, condition and so forth being yet unavailable on account of departmental regulations.) These things having been accomplished, Dr. Marbut revises his opinions, and, that reliable information which was lacking now having become available, he enunciated the doctrine that (according to the studies made by German specialists, and provided the results of his experiments are applicable generally): "The accumulation of a thick layer of forest debris, such as that which accumulates in the forests of the Lake Region, is injurious not only to the soil but to the forest. Anything which can

prevent such an accumulation will not only not injure the soil but will benefit it."

Were all this merely a matter to be mooted among scientists, pending experimental determinations of greater particularity; were it merely a matter of laboratory technique, or of shades of meaning among trsnslators, no presentation such as this might be justified. But in this situation there is a perversion of science and the promulgation of a doctrine so pernicious as to permit of no half-way measures in its rebuttal To acquiesce, not to say to advocate, the needless and wanton destruction by fire or any other means, of the age-old, scant and precious organic material of our Lake State forest soils, and this as of being a benefit to the soil, is not only a scientific absurdity, it partakes of the nature of a public outrage.

University of Michigan, March, 1920.

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THE CUT-OVER LANDS IN RELATION TO AGRICULTURAL USE.

BY J. F. COX

Approximately one-third of Michigan's total land area may be classed as undeveloped land from an agricultural standpoint. This immense tract of millions of acres is, in the main, cut-over land situated in the Upper Peninsula of Michigan and in the northern half of the Lower Peninsula, a comparatively small area of land under standing timber, and extensive areas of poorly drained land, most of which is muck. The cut-over land was cleared for the most part thirty years or more ago. The holding of large tracts by individuals, the presence of stumps in the cut-over, and the poorly drained conditions of other areas have prevented the development of this great tract, during the period that the more easily cleared prairie lands of the West were rapidly taken up in spite of their great distance from eastern markets. Michigan's undeveloped area represents one of the few great reserves of land, suited to agricultural purposes, awaiting development.

AGRICULTURAL VALUE.

The extreme variability of the soils of this area has been another factor which has markedly delayed its development. On the better soils, scattered throughout this northern region, numerous instances of successful and profitable agricultural development may be found, but in these same areas a great number of attempts on the part of pioneer farmers to make a livelihood at farming have failed, due chiefly to the fact that they were unfortunate in their choice of land, either selecting land too poor for profitable agricultural development, too remote from developed markets, or were unskilled in farm practice.

It is a most regrettable circumstance that during past years and at the present time a large proportion of incoming settlers have been encouraged in the purchase of land unfitted for profitable development by short-sighted speculators with an eye to immediate profits. These "land sharks," as they have been justly called, have frequently used, as examples, successful settlers on better lands in the immediate vicinity to aid in making sales, and have taken advantage of the ignorance of prospective buyers in establishing them on inferior soils from which, under present conditions, it is impossible to wrest a suitable livelihood by farming. This condition has not only greatly retarded the development of the entire region, but has brought great loss to the state, to the individual who attempted settlement, and seriously injured the possible business of reliable land developers who have attempted to encourage the settlement of land of good quality. The maxim "*caveat emptor*" is a poor guide in empire building, and even a few of those engaged in the sale of lands who do business on the "let the buyer beware" basis can greatly retard the legitimate and ethical efforts of a majority of honest land dealers.

GOOD LAND AND POOR.

Close observation of extensive areas of northern Michigan lands and of present farming conditions in these localities has convinced the writer that there are great areas of excellent soil, capable of high-crop development, and of sustaining prosperous farming communities if rightly handled. On the other hand, there are even more extensive areas of frosty light pine plains, of extremely light hardwood soil, of poorly drained lands and of rocky areas which, under present conditions, cannot be utilized for the profitable production of crops. While areas of both types are often found in comparatively large tracts, they are to a great extent intermingled, which makes great care in the selection of land for development highly necessary.

CROPS ADAPTED TO THE NORTHERN CUT-OVER LANDS.

The experience of occasional farmers and experiments at the Upper Peninsula sub-station and throughout the region have demonstrated the fitness a wide range of crops to the climate and better soils of the cut-over region. It is also an apparent fact that through ignorance or design the cropping possibilities of certain sections have been grossly misrepresented to prospective settlers, and through lack of sufficient knowledge many farmers are attempting to produce crops not suited to the climate or the soil.

Generally speaking, the better sandy loams, loams, and clays of the entire cut-over country are well adapted to clover, grasses, and other forage crops which can be depended upon to furnish excellent pastures and meadows. At the present time the grazing of cut-over lands with sheep and cattle is undertaken with more or less success. The better types of soils are naturally seeded to June grass, alsike clover and timothy. The heavier loams, clay loams and clays, where second growth is not too thick, carry good pasture throughout summer seasons. On the lighter loams, the pasture tends to dry up and run short. The light pine and hardwood soils and Jack pine plains are of little value for grazing purposes, except for a very brief period in late spring and early summer, when they offer light grazing.

After clearing, the loams, clay loams and clay can be depended upon to produce excellent crops of rye, barley, oats, spring wheat, root crops, peas and oats and buckwheat. Winter wheat is gaining rapidly in acreage, and bids fair to become a dependable crop on adapted soils.

Corn can be depended upon on the above-named soils for silage purposes in the lower part of Menominee and Delta Counties, throughout the northern part of the Lower Peninsula and along the southern shore on adapted soils of the Upper Peninsula. Early varieties are dependable for grain, but these regions cannot be termed "corn lands" in the sense that corn can compete with barley or oats as a feed grain.

The well-drained loams and sandy loams of northern Michigan, in general, are splendidly adapted to potatoes. It is well within the realm of possibility that northern Michigan will become one of the greatest centers of potato production in the United States.

One of the problems of feeders, who have recently brought stock into upper Michigan, is to provide for winter feed. Summer pasturage is plentiful. The clearing of more land for the production of barley, rye and oats for grain feed, of silage, root crops and clover and timothy hay, and alfalfa to winter over stock, will make this business much more secure.

Certain areas of the Upper Peninsula can produce all crops necessary to sustain a thriving dairy and livestock development. The Ontonagon Valley, for instance, a great range of approximately 250,000 acres of strong clays and clay loams of high fertility, can produce the grass, grains and winter feed such as roots, peas and oats, or possibly sunflowers and early corn varieties for silage to maintain a profitable dairying or beef cattle industry.

At the present time at Ewen a cheese factory and creamery is maintained. The same condition exists in Chippewa County, which has been a profitably farmed timothy and small grain region for a number of years Great diversity of crops and proper drainage in both these regions is advisable.

In Menominee, Delta, Dickinson and part of Alger Counties are large areas of loams, and less extensive areas of clay loams, well adapted to farming which have been taken up to a comparatively small extent. Loams and better sandy loams of this region offer excellent conditions for potato growing. The rotation of rye or spring seeded small grains with clover is well adapted.

In the northern part of the Lower Peninsula and the Upper Peninsula considerable development has been accomplished on the better lands, but there still remain large areas of excellent land awaiting clearing

In briefly stating the situation the following facts stand out.

1. Michigan possesses a vast area of undeveloped land.

2. For the most part this land is stump land or poorly drained land, which will require considerable time and expense to prepare for cropping

3. Long-time loans at a low rate of interest would be of great help to individual farmers.

4. The soils are extremely variable A comparatively large acreage is well adapted to farming, and an even larger acreage can be termed unsuited for farming under present conditions.

5. The agricultural possibilities of this area are frequently misrepresented to the detriment of its development

6. With proper crops, under the right conditions, a great development of successful farm communities can be made, much to the benefit of the state.

7. Forest fires cause great damage to incoming settlers, a great loss to standing timber and the young growth, and injury to soils through burning out of organic matter. More adequate forest-fire regulation to remove this menace is necessary.

8. *A state agricultural and soil survey to properly designate the value of land for farming, grazing and forestry purposes and adequate fire control are necessary for the sound and reasonably rapid development of Michigan idle lands.*

9. Settlers must in all cases be established on the good lands only and prevented by an interested State from dissipating their energies on land which can not be profitably worked. In no case should they be permitted to be persuaded by the occasional ignorant or unscrupulous land dealer to settle on Jack pine and light blueberry plains and other inferior areas. The right type of land dealer should receive all possible encouragement, and, on the other hand, proper laws should be established to deal justly with the

speculator who, through ignorance or design, misrepresents the agricultural value of land to the incoming settler.

10. Michigan's northern country has been represented both as a great desert from an agricultural standpoint and as "clover land," a coming Eden. Somewhere between the two statments lies the truth. On the whole, Michigan has in her undeveloped northern country a region of great agricultural potentiality, which, if properly developed as farming land, grazing land and forestry land, in accordance with its fitness from a soil and climatic standpoint, will add materially to the wealth and prosperity of the State.

Michigan Agricultural College.

•ECONOMIC ACTIVITIES AMONG MICHIGAN FARMERS.

BY WILBUR O. HEDRICK.

The popular outlet for the country man's economic interests at the present time is organization. The farmer is taking to organization for business purposes in a way which quite dissipates his reputation for social aloofness and individualism. The Non-Partisan Leagues of the Scandinavian Northwest are the most spectacular proofs of this, but the thorough way in which the Federal Department of Agriculture is organizing the farmers of every county into Farm Bureaus promises to be the more permanent. Probably the increased facilities for getting together, both spiritually and physically which we now enjoy, have had much to do with the current furore for organization among farmers, but there are elements of class feeling and strife in the matter also. The idea of the strength which comes from union has been slow to penetrate the rural mind, but there are signs that the farmer has caught the notion and agricultural guilds may soon be quite as common as unions among laboring men and combines among business men.

Two ventures in applied economics along organization lines by Michigan farmers furnish the material for this paper. They are naturally of microscopic smallness in a year given up to post-war readjustments, but they are fairly typical of activities among farmers everywhere and their proximity in place has opened them to rather thorough study. They are named appropriately the Michigan Milk Producers' Association and the Michigan Potato Growers' Exchange, and consideration of each will be taken up in the order named.

The complaints of dairymen with regard to milk prices have furnished newspapers with many sensational headlines during the past three or four years of rural discontent Dairying, as is well known, is a highly specialized type of farming, needing a large fixed investment, skilled labor and valuable trade relations. It is not easily entered into, nor easily abandoned. The high war prices were peculiarly hard upon the dairyman. His feeds for animals and dairying materials mounted to unheard-of prices. On the other hand, city prices were based on a milk as a beverage basis without regard to the fact that as a food milk ranks with the highest. Prices upon the old-fashioned unbottled milk basis still prevailed, ignoring the worth of the processed, pasteurized, bottled and iced product which is now sold.

For some length of time the city distributor of milk was looked upon by the dairyman as being his oppressor, and in not a few cities of the state farmers undertook the co-operative distribution of milk. But it was soon found that this elimination of the middleman was no solution of the problem. The dairyman's costs between herd and city consumer was still in excess of the price paid by the customer.

The next move on the part of the dairymen was to organize the supply, and since this has now become the customary procedure in every large milk

market the country over, it may be worthy of detailed notice. The first meeting for milk supply control ever held in the state assembled at the college in 1916. It was attended by several hundred dairymen and was followed by two more largely attended meetings at the same place before an organization was completed. The association now numbers about 15,000 members and has approximately 160 locals, the largest of which is that of the Detroit area, the membership of which equals 8,000. This one local sells, through agents, $9,000,000 worth of milk per year and has secured from the Detroit dealers recognition to the extent that all differences must be arbitrated and no milk may be bought except from the locals. The similarity between this dairymen's association and labor unions, which the terms here used disclose, is still further shown by the newspaper terminology of milk strikes, milk picketing, etc., of which we have read so much Furthermore, they maintain the closed shop by obliging dealers to buy only from them and a closed monopoly by not allowing increases of herds without permission.

The price of milk to the Detroit city consumer has risen approximately 100% since the organization of these associations, and any hindrances to still further advance are not very obvious.

Turning now to the weapons by the use of which the country dairymen have been able within so short a time to achieve so much and we find them of the soundest economic sort First, milk is showing itself to be essentially a necessary city utility like water and gas. It has no substitutes and is indispensable to children. Second, through the city Board of Health requirements only inspected dairymen may sell to the city market. This is a license which potentially organizes a city's dairymen involuntarily. Third, milk is a perishable which is necessarily local in its market. Detroit dairymen, therefore, have a monopoly of the Detroit market since milk shows such decided immobility. Fourth, milk is produced upon the contract system. The city dealer, in order to have a dependable supply, engages annually the herd yield of his country patrons and this gives a permanency of relation between these two which it is hard to break. Fifth, dairy farming requires a relatively large fixed investment which makes it difficult for new men to break into the business Competition is, therefore, slow to act among dairymen.

The most natural result from this fact of licensed producers handling a local product which is a public utility to cities upon a contract basis over long-time periods is to give rise to monopoly. The producers need only to be awakened by a business crisis to their real status and organization of the monopoly sort is sure to take place. This is what actually developed through the stress of war in 1916. In this year the city dealers being already organized into a trade association, the milk prices written into the contracts were arrived at by regular collective bargaining between dealers' and dairymen's associations. In the following year these two associations having by this time found their identity of interest united in securing the appointment of a commission from the governor, known as the Detroit Milk Commission, through whose findings the Detroit milk consumer has been made to pay the maximum price and still allow enough to be sold to return the highest profits. The commission is still in active service, and it is now an accepted truth that owing to the monopolistic nature of the milk supply

cities must have these commissions or undertake municipal handling of this commodity

The second organization is simply a farmers' co-operative association, but owing to its huge size and ambitious program it is worthy of our attention The Michigan Potato Growers' Association is the name to which this undertaking responds and its headquarters are at Cadillac, while its membership is scattered through the twenty or more northern counties of this peninsula. This potato shipping association is the natural outgrowth from the acute potato depression which prevailed in Michigan two years ago. The organization consists of 90 local associations scattered through half as many counties and a federated central office situated at Cadillac It has more than 20,000 members. During the past winter more than a thousand cars of potatoes have been shipped by this central office and as many more remain to be shipped

The whole plan is simply a scheme for getting rid of the local potato middleman, and this association, unlike that of the milk producers, makes no attempt to influence prices Potatoes are simply shipped each day by the central office to the market where the highest prices may be found. It is the fact that this is done in the interests of the farmer-producer rather than in the interests of the middlemen which gives merit to this method There is no monopoly possible in connection with potato distribution, since we compete with many other states for the same city markets

The locals require a rather heavy membership fee, since each must employ a local manager and secure a warehouse. In addition to a cash membership fee each member also contributes his note for $100 running a considerable length of time and without interest This gives the local more operating funds and tends to hold the group together These locals average 100 members each, and in the county of Antrim, out of 1,500 inhabitants, 800 are members of some local. Any member may sell his potatoes at any time he wishes to fill or help fill a car. The central office will get the highest price obtainable on the day of marketing and will return to the farmer-grower the full receipts for his shipment less only the costs of marketing The fruit growers of western Michigan have adopted a similar plan, and 90 co-operative grain elevators have done likewise. Several other agricultural subindustries are taking steps toward the same end.

It is interesting to note the attitude of public authority toward farmer organizations As was said before the county organization of farmers into bureaus is being actively promoted by employees of the government As is well known too, the Clayton amendment to the Sherman anti-trust law exempts both labor unions and farmers organizations from the operation of this statute. Farmers organizations are also exempt from the business corporation tax, provided they do not issue stock shares nor divide a profit into dividends. The "Hoover" food law also exempts farmers' organizations from the licensing provisions of this statute so that there seems to be nothing but encouragement for farmers to organize, whether into monopolistic businesses like the milk producers, or competitive ones like the potato growers.

Michigan Agricultural College.

THE ENCOURAGEMENT OF THRIFT.

A SUGGESTION IN PERSONAL TAXATION — ERNEST F. LLOYD.

Having in mind our American predelection for rainbow chasing, I feel a certain reluctance in approaching the subject of my title. Nevertheless, it seems to me that it would be entirely possible to devise a personal income tax of such character as would definitely encourage thrift, or, perhaps more properly curtail extravagance. To define the grounds for this belief and to suggest a principle for its application is the purpose of this address Obviously, my approach is social. I feel it proper to emphasize this at the start, because the production of revenue is not the motive in mind. I therefore stress particularly that the method of taxation which I shall suggest has as its sole object the restraint of extravagance The taxation to be suggested is entirely incidental to this main purpose and a part of it. Consequently, it must not be judged as a revenue measure Quite the reverse, for the less revenue produced by it, the more effectively would it accomplish its object Therefore, from the standpoint of raising public funds, it would be merely incidental, a rider, so to say, on the tax laws.

I would then, for our purpose, define thrift as the converse of extravagance So defined, it means not parsimony nor penuriousness, not avarice nor illiberality, but rather an appreciation of the more solid realities of life, a wise economic restraint, a conservation of energy. It involves an ability to distinguish between expenditures for "social production" and expenditures for "social overhead" The man of thrift realizes that civilization exists only by human effort expended in excess of immediate hand to mouth subsistence, that life is many sided—a complexity of needs, wants and aspirations. All of these absorb human effort—human service—human sacrifice—disutilities In this complex, he is thrifty who can hold a stern balance, who can employ the rewards of his effort wisely, who produces more than he consumes, who demands for himself the least effort from others Thrift involves a capacity to understand generic values

Every individual is a social asset or a social liability. That is to say, each individual produces either more, or less, than he consumes. (You will note I do not say that he receives more or less than he produces. The question of the distribution of the economic production is not one for us to here consider) If the individual is a social liability he is outside our discussion, for he would belong in the sub-subsistence group and would not be reached by the scheme of taxation to be here suggested We therefore narrow our consideration to that group whose incomes, however derived, or however well earned or deserved, nonetheless place their possessors above the point of subsistence This super-subsistence group may discriminate and may apportion its income in whole or in part to those purposes which do, or which do not, conserve the interests of the state Therefore, it may, or may not, practice the thrift we have in mind.

Taxation is an act of expropriation by the state. Hence, if we are to advocate any plan of income taxation as a means of encouraging thrift in the individual, it must necessarily take the form of a visible penalty on extravagance. The counter-implication of taxing extravagance must be a freedom from penalty against that income which is devoted to purposes that accord with the general idea of public good. In this, the state is presumed to express the concensus of enlightened public opinion. It would appear necessary then to inquire

First, does any private income serve a public purpose and, if so, how? and

Second, what classes of personal expenditures conserve the social good and why?

Consideration of our first point will involve us in conflict with many popular fallacies. Chief among these is that one which regards private property as conferring benefit only upon its legal possessor. I shall endeavor to show that the *usufruct* of the great mass of private property under our capitalistic civilization actually resides in the public. Let us then ask, what is capital, how is it acquired, accumulated, and used?

Starting from any moment of time—any given date of the calendar, if you choose— the human beings on the earth at that moment find themselves as a totality in possession of many instruments of (*a*) subsistence, and (*b*) production These in total constitute the nation's material wealth, accumulated partly by those living at the date of inventory and very largely by those who have gone before The first of these instruments, (*a*), are comprised in the existing stores of food and clothing and in the homes of the people. The second, (*b*), are comprised in the factories and machinery, the highways and other public works, institutions of learning, records of past achievements and other media through or by the aid of which more subsistence may be produced. It is this second group of instruments that constitutes what we call capital goods, or capital. You will observe that I have made a distinction between wealth and capital. Wealth is the totality of the national inventory, while capital is that portion of wealth actively devoted to further production I should also perhaps say that I speak in general or popular terms. Some of the capital is communally owned, so that the individual is not conscious of any personal proprietorship in it, exercises no personal control over it and consequently describes it as being owned by government. It is public property Some of it, on the other hand, is under the control and direction of private individuals and is regarded as being owned by those persons through their having been invested with what we call a legal title It is private property.

Now the totality of persons constituting any governmental group, making use in various ways of all these public and private capital instruments, produce in the course of any year, let us say, a certain additional quantity of product During the year, also, they consume a certain quantity of product. At the end of the year a new inventory would show either more or less totality of goods or wealth than existed at the beginning of the year. Assuming that the later total is larger than the earlier, because, on the whole, the world's wealth increases, then the *increase*, together with that which has been *consumed* in the year, constitutes in a general way what we term the national income.

It is this national income with which we are concerned in any scheme of personal taxation designed to encourage thrift or, perhaps I should more properly say, to discourage extravagance.

From the preceding analysis, we may see that the national income is divisible into three main parts:

1st. That which the nation actually uses up, or dissipates, as food, clothing, amusement, travel, and other consumptions or personal services

2d. That which is permanently reserved by the recipients for their personal use, to give off its services to them over a more or less extended period. Such are houses, furniture, pictures, books, landed estates, motor cars, yachts, etc

3d That which is devoted to an increase of capital goods, as tools, machinery, investments in bonds, stocks, or private businesses, or bank deposits

This third element only is the capital which I set out to define, and, as we have seen, arises out of the surplus production of human effort—directly or indirectly. Stated differently, it is the residue of production—that portion which is left over after deducting the first two portions enumerated, namely, that which is consumed plus that which is not actually consumed but is reserved for private enjoyment, and so is privately consumed through a relatively extended period In all this, I am speaking in a general or popular sense rather than attempting to split technological hairs. It is at this third point, in my opinion, that we encounter a popular fallacy in regard to capital. It is very easy to see that the individual alone is the direct or immediate beneficiary of that first portion of the national income accruing to him and which he consumes A loaf of bread benefits him who eats it, not him who looks on. So, too, in respect to the second point: a comfortable house and its luxuries benefit him who is inside, not him who is outside. But, as to the third point, it is by no means so clear and easy to apprehend that an individual's private deposit in a bank, or his investment in bonds or stocks, or in plows or ships, is not of any immediate production benefit to himself, but, quite the contrary, is actively serving him only as one of the group or public at large

Probably I should develop this theory somewhat further Modern industrial activity, or production, is based on a complicated system of credit and exchange. Save perhaps in the case of the farmer, no man consumes any of the direct product of his own labor On the contrary, he receives only a claim check which, in the form of wages, salary or other remuneration, in theory represents the relative significance of his personal contribution to the total production. If he be the owner of capital, he receives also interest, dividends, or profits as the case may be, which are also derived from production and, in the last analysis, from the same sources as wages. All, together, comprise the national income whose disposition falls under the three general heads I have previously enumerated.

Having obtained his claim check, or income, in the form of wages, salary, interest, dividends, or profits, the individual may then proceed to surrender all or part of it in exchange as I have noted. If he exchanges the entire sum for goods and services which he consumes or reserves, there

will be, so far as his contribution is concerned, no accretion to the world's supply of capital goods. He will, as we say, "live up his income." The world is, economically, neither better nor worse off than it would have been without him. He is an economic zero. But suppose he does not so consume and reserve his entire income? Then whether he will or not, under our modern credit and exchange organization, there is an increase in the world's capital goods—an increase in the world's instruments of production. This point perhaps may properly be explained somewhat more fully.

It will no doubt be obvious that if the individual is in business on his own account and from his own income or profits, if you choose, he buys more machinery or other instruments of production, he has thereby added to the world's store or stock of capital goods. By the same token, if he is any sort of employer or capitalist and with any part of his income buys stocks and bonds, he has furnished from his income the means whereby such capital goods are bought by others. And similarly, that portion of his income which he merely deposits in a savings bank is loaned by the banker for use in production. The bank simply becomes the depositor's investment agent. In short, whatever of his income the individual does not immediately use or reserve for himself, automatically finds its way, directly or indirectly, temporarily or permanently, into the channels of industry, using the term industry in its broad sense. And not only that, it finds its way there instantly. Perhaps it would be more correct to say that the national income swells the capital fund as it is produced and *remains in that fund unless and until it is withdrawn* for personal consumption by the individuals, the private owners, in whose names it stands This is what I meant by my earlier statement that the usufruct of the great mass of private property constituting the nation's capital, resides in the public. The owner of capital has ultimately two rights and two only. First, he may direct to what public purpose his capital shall be devoted. That is, he may say it shall be used for producing steel, or lumber; in steamboats, or railroads, or what not. And second, he may at any time he chooses withdraw it from such public use and consume it himself Both rights are, of course, valuable. But the point of importance to the nation and to this discussion is that until the owner does so withdraw it, the nation has its use. In short, the owner of capital, the capitalist, large or small, for so long as he continues to be a capitalist, is merely a director for the public. In a sense, he is a trustee with a reversionary interest.

Of course, the owner of great capital has theoretically a large power to influence the kind of activity in which a group may engage. In other words, it presumptively lies in the decision of the capitalists to direct the nation's industrial activity into such channels as they may think best. In point of fact, however, they never exercise, nor can they practically exercise, this theoretic power. On the contrary, the public solely decides to what use the individual's capital shall be put. It so decides through its willingness to pay a relatively higher price for some products than it will pay for others. These unsocial productions therefore yield what we call greater profit, which in turn controls the flow of private capital. I shall later discuss the social significance of this fact. I here only note that, as Von Wieser ably says, "Those goods which will be sold at the highest prices attract the most means

of production." (Natural Value, Chap. III, p. 51) There are certain modifying conditions to this principle, but they do not essentially alter its action.

In a measure, too, the private owner has theoretically the power to speed up industrial activity or to halt it. Yet, here again the real motivation rests in the public. For the private producer will always respond to increased demand and he will himself never halt the supply. The motive for cessation of industrial activity always appears first on the demand side.

It is also a popular fallacy that it lies in the capitalists' power to apportion the distribution of the national income in wages. This is perhaps the most subtle of all popular economic fallacies Wages are in fact determined by the significance of labor. The employer is little more than the interpreter of that significance It is doubtful, in the last analysis, if he can possibly be anything more. It may be, and no doubt is true, that special circumstances exist wherein the employer may be able to reserve to himself as profits an excessive share of the economic significance of himself and his employees as a producing group. But in all ordinary cases, competition between employers regulates the individual employer's share just as competition among workers fixes the wages paid in any industry, while the significance, or "utility," or "value" of the product to the public absolutely limits the total wages and profits. However, detail on this phase would perhaps be aside from our theme.

Finally, though, it does both theoretically and actually lie within the power of the super-subsistence group, acting simply as every-day individuals, to determine to what extent the surplus national income shall be devoted to personal or to public use That is to say, we have seen that an increase of capital goods can come only from the savings of this group. If, then, those who have these greater incomes spend in any year their entire incomes for consumption and reserved goods, there will have been no accretion of capital. On the other hand, if the super-subsistence group has been frugal in its living and personal expenditures, then there will have been a proportionately large increase in capital Stated differently, at the end of the year, the nation will be in possession of added means whereby, in the succeeding year, it can increase its national income over the preceding year, and so have more product.

If my reasoning be correct, then it is evident that such citizens as Russell Sage and Hetty Green were great public benefactors. This was why I said that consideration of my first point would involve us in conflict with many popular fallacies. And if I have made the reasoning clear, we see that thrift is an expression of patriotism That it is first and above all a public service. Whether or not it is conscious public service is of no consequence here.

I come now to my second main point, namely, to inquire into what classes of personal expenditures conserve the social good and how? As we are not formulating a tax law, we need not attempt anything in the nature of a complete enumeration. Instead, we are concerned with principles, which I shall endeavor to illustrate rather than define.

I conceive then that it is to the interest of society, or the state, that every individual within its jurisdiction should be nourishingly fed, seasonably clothed and protectively housed. I do not mean to say that they need feast on quail, wear silk hose, and live in a palace. I do mean that the

state is stronger and its civilization on a higher plane if no one within it is chronically hungry, cold, or poorly sheltered. Mark that I do not say that it is the *duty* of the state to provide the needed minima—that is a different and perhaps open question. I simply assert that it is to the interest of the state—that it is of social value—that such wholesome conditions should exist among a people. Therefore any individual who consumes from his income the needed sum to provide himself with such minima is practicing true thrift and should not be penalized on such expenditures. I, of course, do not pretend to set exemption limits, though there would seem to be good reason to err, if at all, on the high side.

It may also at this point be well, parenthetically, to examine the sources or causes out of which flow the unsocial productions to which I previously alluded. That is, to inquire how it comes about that industry will provide luxuries for the super-subsistence group in preference to providing necessaries for the less economically fortunate. Let me again quote Von Wieser: ". . . Production is ordered not only according to simple want, but also according to wealth . . . It is . . the distribution of wealth which decides how production is set to work The beggar and the millionaire eat the same bread and pay the same price for it: the beggar according to the measure of his hunger, and the millionaire according to the same measure, that is, according to the beggar's hunger. The price which the millionaire might be willing to pay for the bread, supposing he were hungry, and driven to offer his maximum, never comes into the question . . but the more the ability of the rich is spared in the purchasing of necessaries, the greater are the means which they have over, wherewith to extend and increase the prices they offer for luxuries, and the more defective is the impulse given by consumption to production." It will be observed that the quotation contains the principle underlying my previous statement that the public, through its willingness to pay a relatively higher price for some products than for others, thereby itself decides to what purposes the private capitalist will devote his capital. I do not say that this is either unwise or inexpedient. It is at least self-determinative and that perhaps contains a measure of virtue that should not be overlooked by those who would advocate measures of empirical control I interject the parenthesis only to show the economic basis of unsocial production the stimulus to it and as a further argument for the desirability of checking the unsocial tendency by measures which might be expected to encourage thrift.

Returning to my theme, I wish to especially emphasize that all the figures I am about to use are purely arbitrary and are employed solely for illustrative purposes. They are not to be even remotely considered as having any practical relation to a proper scale of values for any legislation that might attempt to embody the principle of my thesis. For this reason, they are perhaps dramatically conceived. And permit me to repeat that the primary object of the plan of taxation suggested is to restrain expenditures for unsocial purposes and therefore that its success would be in inverse ratio to the amount of revenue produced by it. That is to say, it would fully accomplish its purpose only by yielding no revenue.

Suppose then that income were exempted to the extent of $1,500 per adult as a general exemption with lesser scales for dependent non-producers, such as children of various ages and defectives. Also, that property re-

served by a family group for residence purposes, to the extent of, say, $5,000, should be tax exempt. (I should be particular perhaps to avoid a possible confusion on this point. We are dealing with incomes, so that the exemption of $5,000 of value of property used for residence would take properly the form of an allowance at the rate of, say, 10%, or $500 per annum, on account of rent for a family group of, say, five Or, again, say of $100 per person over five years old). It would, in my opinion, be both impractical and undesirable to in any way attempt any regulation of the character of apportionment of expenditures made from the exempted lump sums above suggested. The individual or family might, or might not, wisely spend such general exemptions. Far better that they be subject only to the corrective discipline of the opinion of their intimate group than that any other coercion be applied.

Such lump general exemptions, however, would not serve all the purposes of the state's best interest in the individual. There are certain specific exemptions which it might be well to make in addition.

(1) I conceive it to be for the public good that the individual should be kept in the best possible health All sums spent for medical service should be exempt, whether paid to private or public health agencies.

(2) So, too, all sums paid to the public treasury for any and all taxes If any such sums add to the value of property and so come under the head of "local benefit" they still add continually thereafter to the taxable value of the property benefited. The individual can receive no personal benefit, save as he shares it with the public, or through his taxable property.

(3) Again, the state recognizes the public value inhering in education I would exempt all sums properly expended in providing education in all those branches of learning that make for a better and more enlightened citizenship

(4) All sums paid by the individual for life, accident and fire insurance either swell other incomes, constitute only a transfer of value, or practically at once find their way back into production, by loan and investments of the insurance companies. They defer or alienate the use of the income by the individual not less than any other of his investments in capital goods.

(5) Sums devoted to philanthropy yield no material satisfaction to the giver and I would exempt them without limit

The application of these principles in a tax law would then take some such form as this. The individual would report his income, say in the manner he now does for the federal income tax. He would then go a step further and divide his reported income into two parts.

One part would comprise that portion *not spent* for personal use This would be the taxpayer's savings It would be the portion invested and in the bank, etc. It would be that portion described as part three, capital goods, and would be exempt in total from all taxation of a personal nature. By that I mean surtaxes or any tax of a differential quality. My idea would not preclude a flat rate income tax if that were decided or found to be the most socially desirable method of raising the needed revenue, though we may have some doubts on that point.

The other portion would be that which *had been spent* for personal purposes, that is, parts one and two as previously described. The sum of this personal outgo, after deduction of the general and specific exemptions,

would be subject to tax. On this taxable balance of the outgo would then be levied a heavy and rapidly accumulating tax. It might be termed a luxury expenditure tax. Let us for illustrative purposes suppose that it be fixed at 10% cumulatively per $1,000 of such excess expenditure. That is, for the first $1,000 of *excess expenditure*, 10%; for the second thousand, 20%; for the third thousand, 30%, and so on. Let me illustrate how such a suggestion would work out:

Suppose that a man and his wife only, with an income of $6,000 a year, choose to live on a scale of $5,000. They would thus increase the national capital by $1,000. Let us lump together the five specific exemptions which I have suggested and regard them as together amounting to $1,000 Such a group of two would then stand, on the basis of my illustrations, in this wise:

Total income			$6,000
Total personal expenditure		$5,000	5,000
Outgo tax free			$1,000
Exemptions—			
Two general, at $1,500	$3,000		
Two rental, at $100	200		
Five specific	1,000	4,200	
Balance of outgo, subject to outgo tax			$800 at 10 %
Total outgo tax			$80.00

So, too, if the income of the above couple were $10,000, or $15,000, or $20,000, and they continued to live on the same $5,000 scale as above, their outgo tax would continue to be only the same $80, for all the balance above $5,000 would automatically be in the nation's capital and so serving a public purpose.

But suppose when the income of this same couple did become $15,000, they should conclude that their former modest mode of life was no longer adequate to express their added importance, as denoted by their larger income Let us suppose then that they decide to move to a more expensive quarter of town, into a larger house, etc., all together involving a personal expense of $10,000 per year. Then, under the suggested cumulative system, there would be an enlarging tax contribution. As previously, they would have their $4,200 of exemptions (provided their specific exemptions did not alter). Their account with the government would then stand·

Total income			$15,000
Total personal expenditures		$10,000	10,000
Outgo tax free			$5,000
Exemptions—			
Two general, at $1,500 each	$3,000		
Two rental	200		
Five specific	1,000	4,200	
Balance of outgo, subject to outgo tax		$5,800	

Computation of outgo tax, on the illustrative basis suggested for cumulation of such tax

First	$1,000 at 10%	$100
Second	1,000 at 20%	200
Third	1,000 at 30%	300
Fourth	1,000 at 40%	400
Fifth	1,000 at 50%	500
Sixth	800 at 60%	480
Total outgo tax		$1,980

But, as before noted, if income increased even to a million dollars a year and the individual chose to live on the simple scale of the $5,000 at which he started, his outgo tax would only be the same $80 as at first.

In effect, the state would say to the individual this: "Private income is invested with the nature of a public trust. If you are wise enough, and capable of sufficient self-restraint to exercise that trust well and frugally, it is to the interest of the state to allow you to assume and discharge that task. You may have your reward in the prestige of administering these large interests and the state can safely entrust them to your care, because as you are frugal about your own affairs you will presumptively be careful in the administration of your trust. As well, if you wish to acquire a large estate, that you may not only have distinction and prestige, but on which you may live frugally for a long period, or permanently, without further economic effort, there will be no penalty attached to your so doing. Conversely, if you merely use your income to indulge in great display, or luxury, or extravagant idleness, you are in effect commandeering the service of others who would else be producing values available for exchange, to the benefit thereby of all, which would advance the public weal. Such personal indulgence is unsocial; you are therefore using your power to the public detriment. But also," would say the state, "we will take only in proportion to your extravagance and in such manner that you will be continually and forcefully reminded of the unsocial quality of your conduct. Not less if you are disposed to be recalcitrant, there will be automatically a limit beyond which you cannot go, because presently this increased outgo tax, plus your actual expenditures, will absorb your entire income. The penalty therefor lies only against luxury, display, extravagance, or like unsocial conduct."

I hope it will have been made clear that the crux of my thesis lies in the theory that all wealth that is not actually consumed by, or reserved for, the exclusive use of the individual is, under our modern system of civilization, automatically and inevitably, serving a public purpose.

It is therefore of paramount importance that the fundamental thought be fully grasped. I am not certain that in this brief presentation I have been able to make it as clear as needful. It may assist if the idea be regarded as in a way a form of proportional, or cumulative luxury taxation, and so of a more effective and socially just type than is possible with specific luxury taxes. With the justification or expediency of these from a revenue standpoint we are not here concerned. But it must be evident that a 10% tax on a \$25 hat cannot but be socially one thing out of a \$5,000 income, and quite another out of a \$50,000 income. Expressed differently, a specific luxury tax is not relative to varying incomes and may not at all conserve or encourage thrift. It may, in point of fact, as we have seen, definitely tend to increase extravagance.

A cumulative outgo or extravagance tax, using Von Wieser's illustration of the price of bread, would tend to make the millionaire's wife pay from her income, for her expensive hat, a sum proportionate to that which the laborer's wife, from her income, paid for her hat. Incidentally, of course, the argument often made that the consumption of luxuries by the rich makes work for the poor, has not an economic leg to stand on. Actually, every luxury produced for the rich, raises the real cost of a necessary for the poor. We might go a step further and put our finger on a fundamental modern problem by saying that luxuries raise the real cost of necessaries.

Finally, let me repeat that life is a complex of needs, wants and aspirations, a riot of vanities, desires and appetites. All these make their demands which it is wholly natural for the individual to satisfy, *if he can do so.* To then expect him to voluntarily curb these satisfactions is on a par with expecting all men to act socially and so justify the abrogation of all laws and conventions. Men never have so acted, they do not so act, and we may presume they will not so act from any ethical motivation within sight of civilization in the year of grace 1920. Nor will any exhortations effectively impel them to do so. But men do act in what they conceive to be their self-interest, and if their self-interest can be made to coincide with the interests of society as a whole, then I submit common-sense dictates following the line of least resistance.

In the last analysis, extravagance is but one, and a rather crude way of attempting to express personal power and importance. It notoriously yields few other satisfactions. Curtailment of it then would simply invite and require the development of other avenues to the same end. These would naturally have to be of a more intimate or personal nature, and we may then not unreasonably believe would lead both to a higher national culture, and to a marked conservation of social resources. This might be expected to eventuate in greater national wealth; certainly in a greater national weal It should also remove or greatly lessen the temptation to extravagance in those of less means through its tendency to render extravagance unfashionable Thrift on the part of the wealthy would perforce tend to become a virtue which would have its inevitable reaction on the less well-to-do In short, it would tend to establish a condition the indirect result of which would be to rate men more nearly for what they really are than for what they possess and to enable all to more nearly have what they really need If such a condition is desirable, and I am one who believes it to be so, then it would seem that we might accomplish some measure of it by a cumulative outgo tax—a tax to encourage thrift.

University of Michigan, April 2, 1920.

THE ECONOMIC COSTS OF RETAIL DISTRIBUTION.

ISADOR LUBIN.

It has long been the custom for economists, whether willingly or through compulsion, to pay some degree of attention to the proficiency of the mechanism which guides and controls the economic activity of man. Though many have time and again insisted that as scientists our duty lies within the domain of the mere explanation and analysis of structure and function, try as we may, it has been found virtually impossible to keep from expressing an opinion as to the efficacy of our economic system. Be that as it may, one cannot deny the fact that from all sides anathema are being hurled at the economist: by the poor, because of the distribution of wealth for which, by some stretch of the imagination, they hold the economist responsible; by the middle classes, for the high cost of living for which the economic laws of the trained economist in some way or other appear to be the cause; by the rich for income and other taxes which are the outgrowth of the over-fertile brain of the academic profession. Indeed, I have heard it said that the present malingering on the part of labor and the consequent shortage of goods are to be attributed to the economist. So it becomes apparent that, do what we will, economists must say something about the efficacy of the present order, be that something commendable or derogatory

Of the innumerable attacks upon the present economic order, by far the largest portion has been made against the machinery of distributing wealth. So, also, those who have taken upon themselves the defense of our present system have met the attackers on their own ground, seeking at all times to justify the present system of distribution, making no mention all the while of the other phases of the science which might account for the existing distribution. Likewise, our social reformers find the panacea for all evils in a redistribution of wealth, and appear never to have considered the fact that should we equalize all possessions today, we might tomorrow conceivably find ourselves back where we were yesterday, especially if the other phases of our economic activity were left untouched.

There has latterly grown up, however, a group of economists who see the solution of our economic difficulties not in the distribution of wealth but in the field of production. To them the problem is not primarily greater possession and consequently more purchasing power; rather they would attack the other side of the equation of exchange and make possible a greater real income through the elimination of the many wastes coincident to the present method of production.

Let me add parenthetically that production in the sense here used implies a much larger concept than is usually attributed to the word. Production means primarily the creation of utilities, and who would deny that those engaged in exchange are not as much included in this category as any one else who plays a part in the economic process? Production as here used, then, includes that category usually considered as exchange, and it is

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at the present system of exchange, though it must be admitted that other phases of production are the object of the attacks of the critics in mind, that the assaults are directed.

It is the object of this paper to look into one of the many branches of production—namely, retail distribution—and describe briefly what in my mind constitutes one of the many weak links of the present economic system. Retail distribution may perhaps be considered one of the oldest of our present economic institutions. Its origin can be traced back to the ancient and medieval markets where the middleman as such was non-existent and where production was begun and completed by the same individual or household. Here were not only form utilities brought into existence, but also time and place utilities, the product leaving the hands of the producer only to go into the hands of the final consumer. That is to say, the utilities of time and place, the creation of which today lies in the hands of the middleman, were the product of the same individual who gave to commodities their form. With the growth of the market, however, such concentration of all productive processes could not continue and there arose a group whose function it was to aid production by removing from the manufacturer as such, the necessity of carrying out the final phases of the productive process. To them was delegated the creation of time and place utilities, or the distribution of the finished product on the market. The early market in which the middleman functioned was necessarily limited and the goods distributed were of a specialized nature. So the individual merchant of early times carried a stock limited in variety, specializing in certain products only, as does to a limited degree the fashionable merchant in our large cities today.

But the need of satisfying the growing wants of a growing population have called forth a greater variety of economic goods with each succeeding generation, and in order to meet the convenience of the growing army of consumers at all times and at all places there has developed a new form of market—the modern retail store with its almost unlimited number of products.

The retail store, like every other economic institution, became enmeshed in the folds of the *laissez faire* philosophy of the late eighteenth and early nineteenth centuries, and in this field of endeavor competition was looked upon, even as it is today looked upon, as the *sine qua non* of efficiency. And with the growth of competition came a growth in the number of retail stores, the guiding motive at all times being the survival of the most fit. Little attention was paid to the exhorbitant price which society was paying for the support of this method of securing the ends which were thought to result from competition. The small amount of capital required to enter the retail business made this an especially fertile field for excessive competition. With the added modern ease of securing capital with which to start on a retail enterprise, the institution has today evolved to that stage where the American small town in most cases has an oversupply of retail stores, and the American public supports a considerable portion of the population in furnishing utilities which might be furnished by less than one-half of the number now employed with a resultant saving of untold millions in land and capital. Indeed, conditions have gotten to such a stage in the American country town that the man who is unable to make good in any other line of endeavor finds a haven in the retail

store. Be he ill, lazy, physically deficient, or even in some cases mentally deficient, his relatives, friends, or the social agency to whose attention he happens to be brought, finds the solution of the problem of his economic independence in the establishing of a retail store of some sort or other where he undertakes to render to the public services which could have been brought into existence without his aid, and for which the consumer seems unwilling to pay him a wage equal to what he might have received had he devoted his energies to some form of unskilled labor which would have resulted in some more necessary and useful form of production.*

Some conception of the situation may be obtained from the fact that there are in the United States today over 375,000 retail grocery stores. These are spread throughout the country in varying numbers: New York, with a population of some 11,000,000 and 35,000 groceries, standing at the head of the list; Illinois, with six and a half million people and 21,500 grocery stores, following, and so on down the list to Nevada with 118,000 people and 344 distributors of grocery products. These figures appear quite significant when we take into consideration the cost of maintaining these competing establishments and compare these costs with the advantages derived from such maintenance. First, there are 375,300 separate grocery stores, each with its own overhead expense that should be mentioned Secondly, we should bear in mind the unlimited duplication of invested capital, the transference of a considerable portion of which to other forms of production would result in a significant increase in our supply of economic goods Finally, in view of the present † shortage of labor of all sorts, one should put particular emphasis on the million odd men and women who as entrepreneurs, salespeople and delivery hands are employed in supplying us with our daily grocery needs.

A hasty statistical summary will bring out more clearly the import of the preceding statements. The state of Arkansas has 1,793,000 people, and for every 226 of them there exists a retail grocery store which represents a given investment in land and capital and the employment of three

*The following quotation from Mr H G Wells in his "History of Mr Polly" describes much better than has been here attempted the present condition of the retail industry

"A great proportion of the lower middle class should properly be assigned to the unemployed and the unemployable They are only not that, because the possession of some small horde of money, savings during a period of wage-earning, an insurance policy or such like capital, prevents a direct appeal to the rates. But they are doing little or nothing for the community in return for what they consume * * * A great proportion of small shopkeepers, for example, are people who have, through the inefficiency that comes from inadequate training and sheer aimlessness, or improvements in machinery or the drift of trade, been thrown out of employment, and who set up in needless shops as a method of eking out the savings upon which they count They contrive to make 60 or 70 per cent of their expenditure, the rest is drawn from shrinking capital Essentially their lives are failures, not the sharp and tragic failure of the laborer who gets out of work and starves, but a slow, chronic process of cumulative small losses * * * Their chances of ascendant means are less in their shops than in any lottery that was ever planned * * * Yet every year sees the melancholy procession towards petty bankruptcy and imprisonment for debt go on, and there is no statesmanship in us to avert it. Every issue of every trade journal has four or five columns of abridged bankruptcy proceedings, nearly every item in which means the final collapse of another struggling family upon the resources of the community, and continually a fresh supply of superfluous artisans and shop assistants, coming out of employment with savings or 'help' from relations, of widows with a husband's insurance money, of the ill-trained sons of parsimonious fathers, replaces the fallen in the ill-equipped, jerry-built shops that everywhere abound. * * *"

†March, 1920

or more persons. Florida boasts of 5,450 groceries, each one of which represents 173 persons in that state. Similarly, Kentucky has an average of one grocery store for every 216 persons. An average of all the states in the Union shows the distribution of grocery stores to be one for every 265 persons in the country. Now, a random sampling of reports dealing with the retail situation in some 1,200 towns shows the average number of persons (including proprietors and hired hands) to be three and one-tenth for each store. On such a basis we may assume that the total number of persons engaged in distributing retail groceries in the United States to be 1,163,600, or approximately 2 per cent. of that portion of our population engaged in gainful occupations last year. But the grocery is but one of the innumerable types of retail establishments that are found in the average American city and town. There are, for example, furniture stores, confectionery stores, drug stores, coal dealers, jewelry stores, hardware stores, meat markets, and many others which need not be here enumerated. In these fields, also, duplication runs rampant. If I should attempt to describe the situation in the average small town of under 20,000 in the United States, the narrative would run something like this:

A—A town in Illinois with some 10,000 people: Two furniture stores, 4 bakeries, 2 shoe stores, 7 clothing stores, 3 banks, 9 drug stores, 4 coal dealers, 2 ice dealers, 3 jewelry stores, 21 groceries, 7 meat markets, 6 general stores and 3 hardware stores.

Or *B*—A town in Tennessee with some 7,000 persons: Four furniture stores, 2 bakeries, 2 banks, 8 clothing stores, 3 drug stores, 4 coal dealers, 1 jewelry store, 10 grocery stores, 4 meat markets and 5 general and department stores.

Similarly in the East, a Pennsylvania town of 7,500 inhabitants, one of a limitless number found in the Middle Atlantic States, shows: Four furniture stores, 4 bakeries, 6 confectionery stores, 6 shoe stores, 16 clothing stores, 3 banks, 3 drug stores, 4 coal dealers, 2 ice dealers, 3 jewelry stores, 22 groceries, 10 meat markets and 5 hardware stores.

And so I might go on for some 1,200 towns in the United States for which data have been obtained. About the situation here in Ann Arbor, little need be said. It speaks for itself.

A survey of the reference book of R. G. Dun & Co. for 1919 shows over 44,000 retail shoe stores in the United States, 52,247 clothing stores, 45,323 drug stores, 30,466 hardware stores, and so on.*

In these four branches of the retail trade alone are to be found some 175,000 establishments, each with no small amount of plant and capital. And it must be borne in mind that R. G. Dun & Co. occasionally fails to list a concern here and there in the country. Here then, roughly, are some half million or more persons to be added to our group who spend their energies creating time and place utilities. I might say in passing that a survey of 16 representative towns in different parts of the United States, having a population of about 15,000 each, showed only one town that had less than 22 groceries, only two that had less than 5 drug stores, only two

*Compare the tabulation of the various trades made by some of the manufacturers of addressing machines and by some advertising firms for an interesting array of data dealing with the number of retail establishments of different kinds in the United States.

that had 9 or less clothing stores, only four that had 4 or less milk distributors, and only seven that had 8 or less shoe stores.

Much more statistical data might be presented which would show the many other phases of the retail situation. The distribution of the various types of stores along geographical lines, the relation which the two different types of industry—manufacturing and agriculture—bear to the amount of duplication, the part which proximity of large cities to the smaller towns plays in determining the number of stores in the latter, and the other similar phases of the situation might be elaborated upon But time does not allow for such detailed analysis.

The question arises, then, as to the significance of the preceding discussion. Is not such duplication as just described a natural concommitant of the competitive system, and does it not lead to certain gains which can be obtained only through such a condition? Evidence in this connection seems to answer this question in the negative Data as to retail grocery prices collected by the United States Food Administration during the war show that food prices were not cheaper in those towns where duplication was most extensive, Indeed, many instances may be cited where the opposite was true.

In addition, duplication of plant does not necessarily mean competition, and the personal observation of any of those present will no doubt lend proof to the statement that there is no relation between the number of retail stores in a town and the degree of competition in that town Rarely, if ever, does experience show falling prices resulting from an increase in the number of retail establishments.

Nor is the justification for the existence of innumerable plants shown by the fact that the consumer is willing to pay for the services rendered by them. Large profits in the majority of retail establishments were virtually unknown in pre-war days, and one would be hardly exaggerating in stating that the average small-town merchant made but a living wage Commercial failures in retail trading in 1906 were almost three times as numerous as those in the manufacturing industry 1907, '08, '09, and '10 showed about the same ratio; 1911 showed a ratio of 9.4 in retailing to 3.5 in manufacturing; while in 1917, a year of unparalleled prosperity and profits, there were 11,923 retail failures, as compared with 3,691 manufacturing failures Yet in spite of the numerous failures in this branch of modern industry the number of retail establishments in existence has shown no decrease. On only one ground does there appear justification for the present condition of our retail situation: namely, that of service. I mean *service* in the popularly accepted sense of the word, and here also there exists room for doubt

Competition, I propose, in the accepted economic sense of the word does not function in the retail trade. Emulation, the desire to supplant one's competitor through the lowering of prices or through better service, seems to have disappeared. Nor does the lowering of prices for competitive purposes secure the benefits for the consumer that might under normal conditions be expected to accrue to him. After a lowering of price the number of plants selling goods at the new marginal price remains the same as formerly, with a continuation of the necessary labor and maintenance expenses; thereby keeping from the real marginal entrepreneur that portion of the sales which would go to him under normal conditions, making ultimately possible

a further decrease in price. That is to say, a lowering of price does not today necessarily mean increased sales and a consequent fuller utilization of plant and labor which in themselves under normal competitive conditions lead to a further lowering of price. Nor is it any longer possible to lower retail prices in the hope that such lowering of price will result in an increased clientele and indirectly to more profits. Our modern attitude toward retailing and the type of person engaged therein has resulted in an institution with a large number of so-called extra-marginal producers or hangers-on who continue in business in spite of low profits, and many of them, indeed, are always hovering about the bankruptcy line* In short, custom has brought about such a situation that it no longer pays to compete in the retail business. The gains to be derived from price lowering are not, in most cases, bestowed upon the one who lowers the price. And so the consumer for whose benefit the institution of competition is apparently maintained continues to pay for the maintenance of the institution with no gain to himself.

Indeed, it may be said that if competition plays any part in the retail industry it is one of determining only the upper limits beyond which prices cannot go; its function is merely potential. This function, however, would still continue to exist even if the number of retail plants were cut in half, because of the mere fact that capital would tend to flow into the industry, once profits exceeded customary levels.

Some will, no doubt, raise the question as to how the retail problem is to be solved An answer to such a question is beyond the scope of the present paper Many contend that the wastes of our present method of retailing cannot be eliminated without a radical change in our economic system, while others see in the mail-order house, a state licensing system such as was recently proposed by a legislative commission in California, the department store or the chain-store system a solution of our problem. At any rate, an efficient system of what might be called consumptional education would go far toward remedying the existing situation.

University of Michigan.

*See foot note on page 1

INTEREST PRIOR TO OPERATION.

W. A. PATON.

The economist is concerned with economic phenomena from the standpoint of an industrial community, of an entire market situation He seeks to discover, for example, the laws which govern the determination of market prices, which are compounded of a complex of circumstances and conditions as reflected in the attitudes of a myriad of buyers and sellers He endeavors to resolve the economic personnel of the community into its primary functional elements, laborer, manager, capitalist, landlord, etc., disregarding, in large measure, the specific personalities of the business world. The economist, in short, attempts to analyze the fundamental processes of the entire economic structure.

The accountant, on the other hand, deals with the business situation on an entirely different level. The unit of organization in accounting—as far as the field of competitive industry is concerned at any rate—is the private business enterprise. No accounting procedure has meaning except as a particular business entity is assumed Every transaction, to have significance for the accountant, must be related to the specific enterprise It is the function of accounting to register the investment of an owner or group of owners in a specific business situation, and to follow this investment as it takes shape in manifold commodities, services, rights and conditions Or, from the point of view of the income sheet, it is the task of the accountant to set up periodic statements of the gross value of the product of a specific business, and to allocate thereto the cost of producing each particular *quantum* of revenue, so that the net change in the situation through a particular period may be stated.

This contrast has been pointed out many times Yet it requires further emphasis in view of the fact that among accountants, at any rate, the situation appears to be very commonly misunderstood. Many of the controversies concerning accounting procedures, many of the fallacious accounting doctrines, seem to arise out of a confusion of economic and accounting concepts and viewpoints Accountants having a very limited knowledge of economics are constantly making use of economic principles to justify certain accounting procedures, although in most cases the economist is talking about an altogether different situation, or is, at least, considering the situation from another point of view.

The many controversies with respect to the treatment of interest in accounting illustrate this confusion. Is interest on investment a cost for the accountant? This is the question under this head which has been most widely discussed For several years certain teachers and professional accountants have been vigorously advocating the affirmative of this proposition. And in their writings and discussions these individuals have freely quoted Alfred Marshall and other economists to the effect that interest is a cost and have used these statements from leading economists as the main-

stay of their argument that interest on investment is a cost for purposes of accounting.

It may be said, however, that the proponents of this view have thus far made little headway as far as securing the adoption of their doctrine in practice is concerned. The American Institute of Accountants has refused to indorse the theory; the accounting profession in general has not adopted it; and the Treasury Department, in its regulations with respect to inventories for tax purposes, specifically excludes interest on investment as an element of cost. The practical difficulties involved (*e. g.*, the determination of the amount of capital to be included and the selection of a rate) have no doubt weighed most heavily in establishing this attitude; but the theoretic objections to the doctrine are clear-cut and convincing. This side of the case was well put, for example, by Mr. Lewis Haney in his reply to a paper read by Mr. Clinton Scovell at the meeting of the American Economic Association in December, 1918. As Mr Haney pointed out the economist's cost of production is not the accountant's cost. The economist is interested in cost as a price-determining factor. And in general his "cost" is numerically equivalent to the price paid by the consumer. Effective marginal cost and price are equal. The accountant, however, deals with cost from the standpoint of the specific enterprise; and this cost is normally less than price—selling price, less by the amount of the margin of net income realized by the concern for its own peculiar services. Interest here is not a cost but simply one element in the net return. Accounting attempts to show this net return as a residuum, a difference between accounting cost and selling price, in which are found pure interest, profits and rents in one conglomerate figure. As well include in cost profits and other payments for the services of the proprietors as interest! Cost to the accountant includes only the *purchased* commodities and services expired, not the peculiar services and functions undertaken by the proprietors themselves. In other words, no services furnished by the owners should be considered as costs to themselves. Any accounting procedure which attempts to include in cost a price for all or any part of the services of the proprietors is unreasonable, and obscures rather than clarifies the situation from the standpoint of all who wish to read the accounts. And in any case nothing that the *economist* says about interest as a cost justifies the inclusion of an estimated item of interest on investment as a cost from the standpoint of the operators of a specific business.

Now I wish to apply the line of reasoning just suggested to another closely related interest problem. What is the significance to the accountant of interest during construction, *i. e.*, interest on investment prior to the operating period? It is a familiar fact that to promote the large scale enterprise, secure the necessary capital, build the plant, acquire raw materials and personnel, is an undertaking requiring considerable time, in the case of a railroad enterprise perhaps several years. What of interest on investment during this period? With respect to practice it may be said that such interest is usually ignored unless a disbursement is actually made. It has been urged by several writers, however, that in *all* cases a fair return on all investment during the non-operating period should be charged to capital. What position should the accountant take on this matter?

Let us consider first a simple illustration of the typical competitive

enterprise. Suppose, for example, that A decides to start in business as a manufacturer. He has a capital of $100,000, which he placed on deposit in a commercial account. As funds are needed for building operations he draws upon this account. At the end of a year, it may be assumed, the plant is completed, machinery has been installed, materials are in stock, operatives have been secured, and A is ready to begin manufacturing. During the year, however, not a wheel has turned; there have been no sales; no income has been realized. Yet, in a sense, the finished plant with all the attendant conditions is worth more than the $100,000 invested. A has had this fund tied up in construction operation for the year (for convenience I am ignoring the probability that, in practice, these funds would be gradually invested). And if the proprietor were now to sell the completed plant he would normally expect more, and would receive more, than $100,000. He has borne the burden of risk and waiting for a year, and would not now relinquish the completed property for the bare amount of his investment.

But should interest on this investment now be accrued on *A's books of account?* Let us assume in the first instance that an affirmative answer is correct and note the effect of the entries which would be involved. Suppose that we say that the value of the completed plant is now enhanced by $6,000, interest on $100,000 for one year at 6 per cent. To recognize this accrual it would be necessary to charge plant (or a special asset account such as interest during construction) with $6,000 and credit A's capital account, or a special proprietary account, with the same amount.

The effect of these entries upon A's balance sheet is evidently the same as that resulting from profitable operation. His assets are apparently increased by $6,000 and the amount of his ownership or equity is enhanced by the same amount. In other words, such accounting would deny that the year of construction was a lean period. A's property has actually increased; liabilities are unchanged thereby; income accordingly has accrued

But let us now recall what was said at the outset with respect to the unit with which the accountant deals. We have here not the general economic situation but A's particular investment. Has there really been an increase in A's assets? If we insist that there has, are we not taking the position that each and every specific investment in the business world inevitably enhances in value with the lapse of time? This proposition could not, of course, be maintained. While investments in general may perhaps so increase, there is no guarantee that any specific investment will even remain intact. It is sometimes said that a business cannot start operations with a deficit, but there is no truth in any such assertion. There is nothing about the construction period which renders a particular group of assets inviolate. Inefficiency or accident may cause large losses during construction. Further, suppose A continues in business year after year and is unsuccessful with respect to operation. He surely would not be justified in complacently assuming that interest is steadily accruing on his investment because of the burdens of risk and waiting which he is carrying.

But even assuming that there were no losses during construction, and that success is assured, should the assets be written up on account of interest accruing prior to operation? The recognition of such an accural would have the effect of increasing the amount of the investment and of lowering

the *rate* of return realized in the later years of successful operation. Is this reasonable from A's standpoint? Is not the construction period literally a lean period, which is compensated by a relatively high rate of return in later periods? There is no question, of course, but that a genuine economic cost is involved from the standpoint of the community; but this fact alone would not justify the accountant in capitalizing the preliminary services of the proprietor on the proprietor's own books. A does not furnish these services to himself. Rather he invests a certain sum in commodities and services. His service consists in doing just this and is not in itself a part of his investment. A wishes his books to register his investment as it takes shape in purchased items, not this amount plus an estimated allowance for the value of the function he is thereby performing.

If interest during construction is to be accrued as a concrete accounting fact, what rate is to be used? A might have left his money in the savings bank at 3 per cent.; he might have purchased victory notes to yield 4¾ per cent., or he might, perhaps, have invested his money in oil stock or German marks and have realized 100 per cent. What is the effective rate involved in view of his decision to invest in a manufacturing business on his own account? It may be answered that bids could he secured for the finished plant which would determine its value and the correct amount of the enhancement This brings us to another aspect of the question. As already stated the completed property would normally sell for more than $100,000 to another manufacturer who wishes to begin operations directly without going through the process of construction. But this selling value would probably be $125,000 or more, rather than $106,000. In other words, selling value—if this were a price-determining case—would tend to exceed cost by the value of *all* the services, functions and burdens furnished and assumed by the original builder, A. Pure interest, profits, wages and other elements would be involved. If this were not the case in which the price-making forces came to a focus, but were rather the typical case, then selling price would be, immediately, a result of the higgling between buyer and seller and, fundamentally, as far as cost is concerned, simply a measure of marginal economic cost.

If, then, there is any effective value enhancement in such a case it is a matter of selling price, and, as has just been stated, the difference between actual investment and selling price is not a mere matter of interest during construction.

As stated above the whole scheme of modern accounting is based upon the idea of showing returns to the proprietor as a residuum, a difference between cost and selling price. This means that the buying market, and never the selling market, is the effective basis for accounting charges. As between enterprises, then, the very same article will appear in the accounts at different values—an apparent violation of the law of single price, perhaps, but nevertheless an entirely rational situation from the accounting standpoint. A, for example, buys materials, labor services, etc., and manufactures a linotype machine. Value on his books is not the selling price but *his* cost. But B, who buys the machine from A, values it initially at selling price to A, which is, however, cost to B. In other words, finished goods in the balance sheet of the manufacturer stand at cost (although it may be desirable in certain cases to adjust this cost to cost of replacement in order

to get an effective cost) and on the books of the buyer are charged to capital asset accounts at cost plus profit to the seller (which includes interest and all the other elements of net revenue) plus freight, handling and installation charges; although the physical character of the article may be in nowise altered because of this change of ownership

Thus the accountant can very properly insist that no materials, goods in process, or finished goods may be valued at selling prices

Now is not this virtually the problem of interest during construction? The difference between the manufacture of a can of beans, a hat, and a linotype machine on the one hand and the organization of a business and construction of the plant on the other is only a difference in degree of complexity and size. In no case should selling price be used on the books. This will mean discrepancies in capital values between different enterprises in like physical circumstances, but perfectly rational discrepancies as I have already tried to indicate Firm A builds and equips its own factory at a cost of $100,000; firm B buys a property physically identical from a construction company for $125,000. From the social standpoint both have the same value, but from the accounting standpoint A has assets of $100,000, B of $125,000. A has invested in raw materials, labor, etc. B has purchased these elements and the services of the construction company as well If operation is equally successful in both cases the *rate* of return realized by A will, of course, be somewhat higher than the rate realized by B And this is just what the accounts should show. The true situation would be obscured not illuminated if a sufficient amount were added to capital in A's case to equalize the rate of return for both enterprises.

Any accounting policy which tends to iron out differences in rates of net income between years for the same enterprise by juggling depreciation charges or other practices, or differences in rates between enterprises for the same year, is to be condemned. The accounts should show the peculiar situation of each enterprise. If A earns 12½ per cent on his investment and B only 10 per cent. this condition should be revealed by the accounts. The capitalization process, entirely reasonable from the standpoint of the investor who is buying a security, in general should not be applied in getting at asset values for balance sheet purposes. Thus we have the accounting rule that goodwill—the capitalization of differential earning power—should never be recognized as an accounting fact unless purchased.

The view that interest during construction is not an accounting fact could, of course, be applied to the case of an operating company which builds certain equipment for its own use. What is the correct addition to capital, cost to the company, or what it would cost to buy the equipment elsewhere? According to this view actual cost is the proper charge. In practice, however, the mistake is often made of including in such an item only the direct costs of labor and material. All indirect costs should also be added.

It should be recognized, of course, that even cost is only a tentative figure. Accounting deals largely with judgments and estimates, not certainties. Valuations are always more or less conjectural and unstable. But a record of cost is in itself a significant statistical statement It gives a fairly reasonable starting point at least. The mere fact that all the assets may possibly soon disappear would not in itself justify the anticipation of

bankruptcy in the balance sheet. The accountant could make little headway without the fundamental assumption that costs give values as a matter of preliminary record. The accountant assumes (as did Marx) that the value of labor and materials expended on a result pass into the result, not as a final conclusion, but for purposes of initial statement and until evidence to the contrary is produced. It would doubtless be impossible to demonstrate the absolute truth of this assumption, and we know that as a matter of price determination it is not strictly true; nevertheless most would agree that it is a reasonable basis for accounting procedure.

To capitalize the services of the owners themselves, would be to introduce a still more tentative and provisional fact than other costs, although this would not perhaps be sufficient ground for their exclusion. It must be admitted that in a sense these services do accrue, at least during the operating period, just as surely as purchased items The economic history of a business enterprise is a continuous stream, and when the accountant attempts to break this stream up into years, half years, quarters, months, or other periods, and allocate to each particular period the facts appertaining thereto, putting a balance sheet stonewall at each end, he must, of course, sever many real connections and proceed in a more or less arbitrary fashion. If a unit of raw material as it makes its way from the storeroom through the various stages of manufacture and finally to the warehouse as a finished article ready for shipment draws into itself the values of all services and commodities expended as necessary incidents of its changing condition, then the economic services furnished by the owners themselves also so attach to the finished article. Or, in other words, the value of the finished good ready to ship is virtually selling price. All this can be admitted, however, and yet we can still return to the objection that the viewpoint of the accountant must essentially be that of the owners, and from this standpoint the value of the owners' functions does not inhere in the completed article for accounting purposes.

Thus far the only illustration considered has been that of the simple homogeneous proprietorship. A complication arises where the capital used in construction is secured from several more or less distinct sources. This is likely to be true in the case of the large corporation. Suppose Company A, for example, secures two millions in cash from two classes of investors, preferred and common stockholders, one million each. The preferred stock is to draw interest (or dividends as you please) quarterly at 7 per cent. from date of issue. The funds secured are deposited to the order of the corporate treasurer and are disbursed upon proper authorizations to promoters, bankers, contractors, jobbers, etc. Let us assume again for convenience that organization and construction cover the period of one year, and that the entire two millions is deposited at the beginning of the year. Then in addition to the other outlays a sum of $17,500 must be paid each quarter to the preferred stockholders, themselves proprietors and legally rating as members of the corporation. This payment must be made from the joint funds as there are no other sources. What is the significance of this disbursement of $70,000 for the year? According to the view emphasized above this sum is simply a withdrawal of capital and cannot be considered as still in the property under the head of interest during construction. If, for example, the company had secured the entire two

millions from a homogeneous group of common stockholders there would have been no such payment and $70,000 additional would have been available for investment in plant and materials. A more valuable property would have been the result. If, then, under this assumption there could properly be no charge to capital for interest on investment, the $70,000 withdrawn prior to operation under the other assumption is a disbursement of capital.

But if this is the case the question arises as to whose equity is depleted, the common or preferred stockholder's. If the preferred members have preferred rights to assets then this payment is really a diminution of the common stockholders' investment. It is not, however, a loss, as the common stockholder is willing to make this concession for the sake of a possible higher rate of return later. It is difficult to come to a decision on such a case. What viewpoint shall the accountant take in preparing the first balance sheet, that of the enterprise as a whole—the managerial viewpoint, or that of the residual equity, the common shareholders? From the first standpoint the actual investment in this case, according to the view I have been trying to establish, is $2,000,000 less $70,000, or $1,930,000, from the second, there is some reason for saying that the investment is the full $2,000,000, as by paying this $70,000 in advance the common stockholders are obtaining a privilege which they doubtless consider worth the sum paid.

If the first view is accepted, what entries would be made to recognize these dividend payments? Since it is customary not to charge the capital stock account unless actual shares are retired the charge concurrent with the credit to cash might be made to an account called "advsnces to preferred stockholders," an account which would later be closed against profits. This would give a peculiar valuation account, not an asset from the standpoint of the business as a whole, but a reduction in the common shareholders' interest, a concession which nevertheless carries with it a speculative advantage to *one* class of owners

The still more difficult case arises where part of the capital is secured through bond issues and interest accrues on such funds prior to the operating period. Here again if the viewpoint of the enterprise as sn operating unit is taken such disbursements and accruals are simply a reduction in the stockholders' equity. The stockholder does not *buy* the services of the bondholder. If both bonds and stocks are issued this simply means that funds are secured by the corporation from two different classes of investors in a sense the bondholders' equity is just as much a part of the capitalization as the stockholder's interest. If funds are disbursed to any of these investors prior to operation they must come out of capital; there is no other source. And the residual equity is of course the one affected. Yet it must be admitted, however, that legally a bondholder does not rate ss an sctive member of the corporation proper; and if the accountant were to proceed from the standpoint of one interest only, the stockholders', and not from that of the balance sheet as a whole, it would not be unreasonable to adopt the view that these payments to certain classes of investors do not impair the assets. I believe, however, that the most reasonable treatment for all such cases is to view these payments as offsets to the original amount of the common shareholder's equity, concessions for which he will be compensated by a corresponding higher rate of return on his true net investment in later years.

In conclusion I wish to comment briefly on the situation in railroad accounting. There is found in the classifications of the I. C. C. a capital account entitled "interest during construction." This account is charged with all interest accruing during the construction period on bonds and similar securities, and "this account shall also include reasonable charges for interest, during the construction period before the property becomes available for service, on the carrier's own funds expended for construction purposes" In other words, not only is capital not to be considered as impaired by payments to bondholders, but capital is to be charged with a fair interest allowance on the stockholders' funds This is entirely logical practice and can be justified in the public utility situation, even though it would not be proper accounting for the ordinary private business in the competitive field. The railroads have become almost quasi-public companies. Their rates are regulated; and the investor in railroad stocks is pretty largely restricted to a non-speculative return In equity, accordingly, the investor should be allowed to earn this lower rate directly from the time his funds are first deposited To the extent, then, that the accounts in the case of railroads should show the value upon which the investor should be allowed to earn, interest during the preliminary period of waiting should be added. The capitalization of early losses, which has in some cases been allowed public utility companies by courts and commissions, is a step in the same direction The suggestions I have made with respect to this problem evidently do not apply with equal force to the public utility companies.

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THE LIMITATIONS OF COST ACCOUNTING.

BY HERBERT N. SCHMITT

This inquiry into the limitations of cost accounting does not propose to be exhaustive. In the short time at my disposal it will be possible for me to take up only the two following points: (1) Can a figure of true cost of product be obtained in plants manufacturing more than one product? (2) Can the individual manufacturer use the figures of cost obtained from his cost system for the purpose of fixing selling prices for his products?

The first question is answered in the affirmative by practically all cost accountants. In a recently published text on the subject appears the following: "*The costs of each article, class of product, or operation being separately shown* the management has the necessary data at hand to guide it in making changes of policy or method"

From another author we have, "Following the general practice described above, material, labor and burden charges will be made against each part. A summary of these charges gives the *complete cost of the finished part*" Still another writer, taking up the question of what cost accounting can do for the railroads, says, "Thus the cost of hauling a car-mile of a given class of commodity over a given section of track would include also its proper proportion of interest charges, maintenance of way charges, equipment depreciation, equipment repair expenses, general expenses," etc. From this quotation it is evident that the writer feels confident that a good cost system would make it possible to get the *cost of hauling a carload of a given class of commodity one-mile over a given section of track*

Let us inquire into the procedure of the cost accountant in arriving at his figures of cost under the Scientific Machine Rate Method. This method is the unanimous choice of accountants when confronted with the problem of getting costs in a plant wherein many products are being manufactured and the conditions of operation are very complex.

Briefly the method of arriving at cost of product under the Scientific Machine Rate Plan is as follows:

The direct material cost and direct labor cost are charged to the product as incurred, and the indirect expense or burden is charged to the product through machine rates. It is assumed that through the use of these machine rates the burden is accurately distributed between the various products manufactured.

In determining these machine rates the plant is first divided into departments, a department being defined by Church as, "any homogeneous group of productive activity." It should be borne in mind, however, that some of these departments are expense departments. They are sometimes referred to as "non-productive" departments, and may be considered as such in the sense that their cost must be distributed over the productive departments where direct process work is done on the salable product.

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When the departmentalization of the plant is completed, the next task is to estimate the total hurden for the plant for the succeeding period, usually a year. In order that a more accurate estimate be made possihle, the indirect expenses are divided into classes, such as buildings expense, power expense, stores transport expense, etc. If the plant has been in operation for some time, records at hand of past performance are used as a basis for these estimates. Should the concern be a new one, the experience of like plants is drawn upon if possihle.

These estimates of future expense or burden are then allocated to the various departments on some reasonable hasis. Upon the completion of this process, figures of total estimated burden for each department for the succeeding period emerge. As stated above, several of the departments are of the "non-productive" class, and their expenses must be absorbed by the productive. So the total expenses of the power department, department of superintendence and supervision and like units, are distributed between the productive departments on bases which under the circumstances will do justice to all shops At this point, then, the total estimated hurden for the whole plant has been allocated to the *productive* departments alone, giving a figure of total estimated burden for each productive department.

The productive departments are taken up one by one and the estimated total burden for each department is apportioned to the production centers within the department. Scovell describes a production center as "a manufacturing unit, or group of units performing similar operations and incurring substantially the same expense per hour used for fixed and operating charges." The selection of bases to be employed in this distribution, as in all the preceding allocations, is mainly a matter of judgment.

When, to these figures of hurden for each production center, are added the estimate of expense for each machine, for its depreciation, repairs, lubrications, waste, etc, a figure of total estimated burden chargeable to each production center for the succeeding period is found. And this amount, divided by the estimate of total production hours that the production center will be kept busy on product during the coming period, gives finally the machine rate for the production center

As previously stated, the accountant's cost of product is the sum of the direct material cost, the direct labor cost, and the burden cost, and in order to determine the burden cost he multiplies the hours worked on the product at the various production centers by the respective machine rates.

But can a figure so obtained be called a *true cost* of product?

When the cost accountant states that he has obtained a true cost of product, he asserts that he has charged to each product manufactured its just and proper proportion of the salaries of the higher officials, wages of the sweepers, and truckers, trucking equipment expenses, watchmen's wages, salaries of supervisors and foremen, superintendents' salaries, power, heat and light expenses, stores department expenses, insurance, depreciation and maintenance charges for plant and equipment, liability insurance, factory organization expenses, etc.

He also asserts that he has estimated with substantial accuracy the amounts of all of these expenses for the succeeding period, as well as the production hours for each production center. The cost experts might urge that the actual expenses are known at the end of the period, and that any

necessary adjustments can be made at that time through the use of the supplementary rate. According to the best practice, however, the true factory cost is the figure shown before any charge is made under the supplementary rate. In any case the supplementary rate method of charging unabsorbed burden is an averaging method and open to all arguments that can be made against such procedure.

It is evident, when the method of determining machine rates is investigated, that the cost accountant's assertions are not substantiated. The matter of judgment enters of necessity into the calculation of these rates and to such a great extent that what is obtained from the cost system is only the *opinion* of the installing cost expert as to the costs in that particular plant. If two equally capable cost experts were confronted with the same situation, and working independently were to determine sets of machine rates, in all probability these rates would not be coincident. In that case a product would have one cost or another depending upon which set of rates was used, or stated in another way, depending upon whose *interpretation* of the facts was chosen. And it could not be urged that one figure was correct and the other wrong, because there is nothing against which they can be checked absolutely.

Therefore, it would seem that because of the existence of common expenses, it is impossible to determine an absolutely true figure of cost of each product in the case of joint-cost products. (This term is not used in the strict economic sense.) The out-of-pocket or direct costs can be determined by the method of differences; but when the problem of distributing the common costs is attacked, recourse must be taken to imputation, often of the most arbitrary nature

Were the burden element a negligible portion of the total manufacturing expenses, figures of cost for individual product might still be obtained which are substantially true costs. In the present era of large-scale production and ever-increasing roundaboutness of method, however, the burden element is not negligible. The indirect expenses, in most instances, constitute a substantial part of the total cost of manufacturing.

Although cost accountants hold in general that the manufacturer can use the costs calculated from a cost system for the purpose of establishing the selling prices on his products, the majority realize that qualifications must be made to any such statement. Nevertheless there are those who state rather roundly that such use can be made of costs

One writer, in enumerating the advantages of a cost system, says: "The management has the necessary data at hand to guide it in making changes of policy or methods, these including:

"(1) Establishing correct selling prices with true costs as a basis.

"(2) Eliminating the manufacture of any articles which show losses, and substituting for these more profitable articles."

Here there is evidently an inconsistency of statement. Since the first statement is not qualified, one would naturally assume therefrom that the manufacturer has the power at all times to establish for his product a selling price based on his cost. If such is the case, why is it necessary to abandon the production of any article merely because a loss is shown? All

that is necessary to remedy the situation is to raise the price of the product to that point where a substantial profit will appear.

Let us assume for the moment that true costs of product can be determined, and take up the case of the standard product. At any one time, under normal conditions, there will be many manufacturers producing such a product, and among these producers there is certain to be gradation in the matter of efficiency. In which case the cost of product is not the same for all producers. Should all of these manufacturers now come onto the market with selling prices for their product established on the basis of their respective costs (which is what some cost accountants state is possible) there would be several prices for the same commodity on the same market at the same time. Such a condition could not endure. The less efficient producers, in order to meet the competition of the most efficient producers, would be compelled to lower their selling prices to the level fixed by the latter. Thus the price at which the less efficient producers would be forced to sell their product would not be a figure *based on the cost of manufacture for each individual producer*. Also being unable to withstand such competition the less efficient producer would withdraw from the industry.

If there happened to be one producer more efficient than the others, who had the productive capacity to supply the whole market at a selling price based on his cost, he would force the remaining manufacturers from the field. In such a case a condition of monopoly would ensue, under which the selling price would be established at that point where the greatest net return would accrue to the monopolist; and a selling price so fixed need not *necessarily* coincide with one based on cost. In all probability it would not.

Or, if we assume that the most efficient producer had not the necessary productive capacity, competition on the part of buyers would bring about a price which made it possible for others to produce the commodity. This price would be above a figure based on cost to the most efficient producer.

It must be evident, then, that each individual manufacturer of a standard product cannot come on the market with a selling price for his product based on cost of manufacturer to himself.

A producer manufacturing a complete "line" often has certain products, the selling price of which is determined on other bases than cost. He may use a particular product as a "leader" to bring new customers into the fold. The prime considerations in placing a selling price on such an article are questions of sales policy. The manufacturer might well decide to sell below any figure of cost that he may have. Then there also may be included in his line other products upon which, according to his cost system, he is not making any profit. But again, because of sales considerations, he continues to produce them. He feels that it is necessary for him to be able to satisfy all the trade wants of his customers.

Another situation in which cost, and certainly cost to the individual producer, does not play much part in the determination of selling price of product, is that exemplified by the automobile industry today. Here production seems to be unable to keep pace with demand. Large numbers of new purchasers of pleasure cars and auto trucks are being added every day to the already large army of present owners. New uses are continually being discovered to which the automobile can be put. Under such conditions

it is not the cost or supply side, but rather the demand side that brings the determining factors to bear in price determination.

Probably the best argument for the use of costs by the individual manufacturer to determine his selling price can be made in the case of submitting bids. Undoubtedly a cost system is an aid to the producer in such a situation, but even here the advantage is less than some cost men would have us think.

For illustration let us take the case of a foundry. A bid is required on a quantity of castings In order that an intelligent estimate can be made it is necessary to know something about the probable amount of material and labor that will be consumed on the job. Cost records of similar work should aid greatly in arriving at close estimates of quantity of material and labor time. These can then be extended into money cost at the current prices, and an estimate of direct cost is thus obtained. The question of imputing burden to the job, however, is not as simple as the foregoing computations. In deciding this question the manufacturer is influenced by many considerations. He knows that in all probability other foundries will submit prices and, therefore, there will be competition for the order. If our foundry man has sufficient work to keep his plant comfortably busy, he may feel that he does not care particularly to get the order unless he can do so at a figure which will allow for charging a substantial amount of burden to the job. On the other hand, if orders are coming in slow and those on hand will scarcely provide employment for his whole organization, the producer will be very desirous of landing the order, and he might, if he were forced to do so by competition, reasonably send in a bid which would cover only his direct costs The burden is practically a constant element in total factory cost, changing very little with the amount of work being done. Therefore, the manufacturer can better afford to take work at prices which will do little more than cover direct costs and thus keep his organization together than to let his plant run at half speed or lie idle.

The figure of "cost," then which the producer uses in making his bid, is a variable one, and is dependent upon industrial conditions in general and upon conditions in his own plant. Stated in another way, it might be said that the individual producer can use his cost system to give him figures of *direct cost*. This shows him the point below which he dare not go in quoting prices. How far above that point he will go in making bids depends in a large measure *upon what he thinks he can get*.

The conclusion is, then, that the individual producer cannot, and does not, use his costs in all cases for establishing selling prices.

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CORRELATIONS BETWEEN MENTAL PROCESSES.

BY NATHAN A. HARVEY.

The material for the present paper comes as a by-product of routine class teaching rather than as a deliberate investigation of a problem in psychological research. The ultimate aim is to discover, if possible, some kind of a test, or series of tests, that might enable one to infer the probable degree of success of a candidate in teaching. Preliminary to that, it seemed desirable to attempt to estimate by means of mental tests the degree of ability a person might have to do school work as a student As an antecedent condition, it seemed necessary to make a somewhat elaborate study of a series of tests which might promise to be of value in these final problems.

Out of a large series of standard mental tests, some forty or more, eleven were selected for special study. These eleven were reaction time, tapping test, rote memory, logical memory, Kraepelin test, substitution test, hard directions, verb-object, free association and information test. These were all taken from Whipple's Manual, or Woodworth-Wells Association tests. The coefficient of correlation was computed between every pair of these tests, using the Spearman Foot-Rule method.

The correlations between these eleven tests were calculated from the records of 334 college students, grouped into eight different classes. The method of giving the tests results in different degrees of accuracy, but the large number of students and the division into eight classes would seem to eliminate a very large part of the error and to make the final result fairly reliable.

The tests themselves are obviously of unequal value, and the accuracy of the results varies considerably in the different tests. They were selected largely because it seemed probable that they would cover a wide range of diverse mental processes We shall not expect, then, to find any very close correlation between them, and in fact we should be surprised if they should show it.

An examination of the table of coefficients will disclose several very significant features. First, the degree of relationship is very low. The highest of the 55 coefficients is only .217, between the verb-object and the Kraepelin test. Seventeen are below .050. These numbers are so small as to be much within the limit of the probable error in any single class. But when we have taken the average of eight classes, we have eliminated a large part of the probable error, and the small coefficient becomes significant. This will be especially noticeable when we observe that fifty out of the fifty-five are positive. In no single class can we observe that less than five coefficients are negative.

Of the five negative coefficients two are included in the group, of which reaction time is one member. The other coefficients involving reaction time are very small, and only one, the one involving the tapping test, is as large

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as the average of the entire number. This result merely confirms again, in another way, the conclusion derived from several sources that reaction time is a circumstance of very little significance in the estimation of mental capacity.

TABLE I.

Coefficients of correlation

Reaction time and tapping	+ 144
Rote memory	+ 005
Logical memory	— 097
Number check	—.052
Kraepelin test	+ 032
Substitution	+ 034
Hard directions	+.018
Verb-object	+ 015
Free association	+ 097
Information test	+.009
Tapping and Rote memory	— 048
Logical memory	+.063
Number check	+ 154
Kraepelin test	+ 114
Substitution	+ 003
Hard directions	+ 070
Verb-object	+ 072
Free association	+ 048
Information	+.043
Rote memory and logical memory	+ 090
Number check	+ 018
Kraepelin test	+ 068
Substitution	+.191
Hard directions	+.101
Verb-object	+.174
Free association	+.104
Information	+ 098
Logical memory and number check	+ 008
Kraepelin test	— 009
Substitution	+ 111
Hard directions	+.088
Verb-object	+.022
Free association	+ 032
Information	+ 110
Number check and Kraepelin test	+.145
Substitution	+.114
Hard directions	+.122
Verb-object	+ 052
Free association	+ 092
Information	+.038
Kraepelin and substitution	+ 187
Hard directions	+ 209
Verb-object	+ 217
Free association	+ 090
Information	+ 001
Substitution and hard directions	+ 101
Verb-object	+.164
Free association	+.110
Information	+ 044
Hard directions and verb-object	+.077
Free association	+.031
Information	+ 060
Verb-object and free association	+ 160
Information	+.066
Free association and information	— 073

In our attempt to discover the relationship between the several tests we can arrange them all in pairs which will disclose the one with which each test shows the greatest affinity When we do this, we see that reaction time correlates highest with the tapping test; the tapping test with the number check, rote memory with substitution; logical memory with substitution, number check with tapping; Kraepelin with verb-object; substitution with rote memory; hard directions with Kraepelin; verb-object with Kraepelin; free association with verb-object; and information with logical memory.

Reaction Time—Tapping	144
Tapping—Number Check	154
Rote Memory—Substitution	191
Logical Memory—Substitution	111
Number Check—Tapping	154
Kraepelin—Verb-Object	217
Substitution—Rote Memory	191
Hard Directions—Kraepelin	209
Verb-Object—Kraepelin	217
Free Association—Verb-Object	160
Information—Logical Memory	110

As a rseult of the comparison of tests in this manner it will be seen that reaction time and the information tests may be dismissed without consideration from any series of tests designed to determine the natural capacity of a person. They correlate uniformly low with other tests that are distinctively intellectual in their nature. In the same way we shall readily

be induced to believe that the Kraepelin test is the one that gives the greatest promise of being serviceable in this connction.

Partly as a result of these considerations, but principally in consequence of adaptability to conditions encountered in teaching large classes, a rearrangement of these special list of tests for special study was made, omitting reaction time and the tapping test To keep the number up to ten, the color naming test was introduced into the series

. The Otis tests are designed to do what had been attempted by means of these ten tests The Otis tests consist of ten series of tests, modeled upon the army Alpha tests, and are described as Intelligence tests. Three attempts were made to give these tests to college classes, but in every case it was discovered that giving the time allowed in the directions made of it no test at all, for from one-fourth to one-half of the class finished the entire series before the time elapsed. A modification was introduced in which only one-half the time allowed by the directions was employed. This makes it rather a speed test, but it seemed to work very satisfactorily

TABLE II

Coefficient of correlation—Otis tests.

Directions and opposites	200
Disarranged sentences	359
Proverbs	262
Arithmetic	160
Geometric figures	230
Analogies	299
Similarities	096
Completion	264
Memory	152
Opposites and disarranged sentences	116
Proverbs	046
Arithmetic	400
Geometric figures	305
Analogies	482
Similarities	027
Completion	269
Memory	461
Disarranged sentences and proverbs	316
Arithmetic	277
Geometric figures	220
Analogies	180
Similarities	207
Completion	312
Memory	359
Proverbs and arithmetic	093
Geometric figures	186
Analogies	150
Similarities	155
Completion	231
Memory	200
Arithmetic and geometric figures	329
Analogies	300
Similarities	220
Completion	307
Memory	407
Geometric figures and analogies	170
Similarities	055
Completion	080
Memory	280
Analogies and Similarities	143
Completion	359
Similarities and completion	227
Memory	155
Completion and memory	377

Computing the coefficient of correlation between each pair of ten tests we notice several significant differences between the Otis tests and the series of eleven tests described before. In the first place the coefficients are all plus. There are no negative correlations. Secondly, the coefficients are uniformly greater than among the other group. The highest is 482, and five are above 400. The lowest is .027, and only two are below .050. It appears that the Otis tests are much more nearly like each other than are the eleven tests of the other group. This fact should not be considered strange nor indicative of anything particularly creditable to the Otis tests, since the tests of the other group were selected specifically to cover as wide a range of mental activities as possible.

In pursuance of the plan to determine the relation between the series of tests, or between the mental processes involved in accomplishing these several tests and a general intelligence, or ability to do school work, the

school records of every pupil in the class for the preceding term was secured. These records are indicated in five groups by the five letters—A, B, C, D, E. Anything that was recorded on the books of the institution was counted, and all were considered of equal value. Arbitrary numerical values were assigned to the letters of the record, and the members of the class were ranked according to the average of these values.

It is doubtful just what the results of such a ranking shows. The same letter represents different values, the subjects for which the record letters are assigned, do not have the same significance, and probably no two persons in the class had letters expressing the values for exactly the same list of subjects In the entire group the five letters may have designated the degree of success obtained in pursuing forty different subjects.

However, we may call this series of recorded marks an indicator of ability to do school work, recognizing its very indefinite character. In fact, as an exponent of general intelligence, whatever that may mean, it would appear to rank considerably below the value of either the Otis tests or the group of eleven selected tests. However, whatever may be the meaning of the record figures, we may seek to ascertain what tests correlate most highly with this ability.

TABLE III

Correlations between the school record and the ten tests.

School Record and Rote Memory	+ 057
Logical Memory	— 078
Number Check	— 008
Kraepelin	+ 255
Substitution	+ 113
Hard Directions	+ 144
Verb-Object	+ 134
Free Association	— 069
Information	+ 079
Color Naming	+ 235

The subsequent correlations refer to the results obtained from only one class. The figures for the ten tests, omitting reaction time and the tapping test and introducing the color-naming test, are exhibited in Table III It will be seen that the correlations are uniformly low. The highest correlations between the school record and any one of the ten test is .255 with the Kraepelin test, and the next is .235 with the color-naming test. Three of them are negative, although none of the negative correlations are more than .100. Two of the positive correlations are below .100. From this it would appear that, so far as any significance at all can be attached to this calculation, the Kraepelin test is the most valuable of the lot.

SCHOOL RECORD AND TEN TESTS—R EQUALS .174.

When we compute the correlation between the school record for this class and the general results obtained from the ten tests, we obtain a coefficient of .174. This is surprisingly low, and would suggest a very careful consideration of the question as to just the degree of validity that attaches to our assumption that our ten tests, or any one of them, constitutes an indicator of intellectual ability.

SCHOOL RECOSD AND OTIS TESTS—R EQUALS .154.

When we insert the results of the Otis tests in the place of the selected ten, the results are even more disturbing. The correlation between the

school record and the Otis tests is even less than that between the school record and the selected ten. It is .154. This would lead us to inquire even more seriously if the trouble may not lie principally in the school record, and in the assumption that the school record may be regarded as a measure of intelligence. May it not be that our assumption that the success in school work is an indicator of the degree of intelligence be more greatly at variance with the facts than is the assumption that the mental tests measure intellectual ability.

TEN TESTS AND OTIS TESTS—R EQUALS 175.

We have seen that the several mental tests, when compared with each other, show relatively low degrees of correlation. When we undertake to determine whether the ten selected tests, or the Otis tests, better measure the ability to do school work, we find that they are practically the same. When we compare the Otis tests with the ten selected tests, we find that the degree of relationship is equally small. The coefficient of correlation between the ten selected tests and the Otis tests is .175, identical with the coefficient between the ten tests and the school record

The result of such calculations is decidedly disappointing. We should be glad to find some single test that would serve as an indicator of general mental ability, or at least of the ability to do school work. Failing in some single tests, we should like to find some small number of tests, such as the Otis tests, that would indicate the same thing. Even if we should have to employ a large number of tests, even seventy-five or eighty, as the Binet tests do, we should not be discouraged. But such investigations as this do not seem to hold out a definite assurance of any such a possibility

The low degree of relationship between the school record, and both the ten tests and the Otis tests, would seem to imply that there are other underestimated and unknown factors, other than the inaccuracy in the test results themselves, that account for the large difference. What these factors are and how to measure them seem to be the subject of a much-needed investigation.

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OBJECTIVISM IN PSYCHOLOGY.

T. S. HENRY

It is the purpose of this paper to discuss certain questions connected with the recent insistence upon objectivism in psychology. I use this term to designate the tendency to limit psychological investigation to such phenomena of human behavior only as are directly observable by an investigator outside of whose own immediate experience they occur, or such as may be said to yield to methods of instrumentation. This tendency is, of course, most noticeable in the work of that group of men whom we know as behavioristic psychologists, or, more briefly, behaviorists. In the course of the present discussion, I wish to indicate a few points of what I consider fundamental error on the part of those who would make behavior and psychology synonymous. I am quite aware that in so doing I run the risk of laying myself open to the charge of being reactionary or unscientific, but in anticipation of the possibility of such an indictment, I wish to reserve the right to plead "not guilty" to both counts. I am also asking you to do me the favor, when some of my statements may sound arbitrary and dogmatic, of attributing such dogmatism to the necessities imposed upon me by the time-limits under which I am working.

I think that it is safe to point to Professor John B. Watson as the leader among objective or behavioristic psychologists, and to say that in his recently appearing book, "Psychology from the Standpoint of a Behaviorist,"[1] we find the most comprehensive treatment of the new psychology. Most of the criticism which I shall voice, therefore, is directed against this work, not for the sake of singling out any particular author, but because in Watson's book I find the most complete formulations of the points with which I am at variance.

What, then, are the objections which may be urged against the behavioristic treatment of psychology, from the standpoint of one who is not yet willing to adopt its complete program?

In the first place, and it is trite to say it, much of behavioristic psychology is not psychology at all, but physiology. This does not mean that it is any the less valuable, but what is gained by "lifting" two or three chapters from physiology or neurology and labeling them psychology? For long years psychologists have recognized the necessity of some familiarity with physiology, especially that of the nervous system, in connection with the proper understanding of the subject matter of psychology, and most writers have given some space in their textbooks to a more or less detailed account of the nervous system, always reminding the reader, however, that such material belongs not to the domain of psychology, but of physiology. We have always felt the connection between these two sciences, in much the

[1]Watson, J. B. "Psychology from the Standpoint of a Behaviorist." Lippincott, Philadelphia, 1919.

same way, though not quite for the same reasons, that we have recognized the connection between physics and chemistry, or chemistry and biology. For years we have had our physiological psychology, though let it be remarked in passing that physiological psychology is neither physiological or psychological in the same way that physiological chemistry, say, partakes of the natures of physiology and chemistry. Physiology and psychology do have points of intimate relationship, and do overlap, as other sciences do. But whereas heretofore physiology has had to be content with a minor place in treatises on psychology, in Professor Watson's book it is granted a place of major importance. Here we find detailed treatment of the general nervous system, the sensorial apparatus, striated and non-striated muscle fiber, and the glandular system. Not only this, but the reflex is singled out, especially in its conditioned form, as perhaps the most significant factor in human behavior. A question might be raised here, also, as to whether the reflex belongs to physiology or psychology, but my own opinion is that we might banish the whole question of the reflex, or at least any detailed consideration of it, and still have left a very fruitful and profitable field for psychological study. If such topics as these which I have just enumerated are to constitute the larger part of its subject matter, there is no excuse for the existence of psychology as a separate science, and it might much better be treated as a chapter added to physiology.

In argument against Cannon's notion of the biological serviceableness of emotional reaction, Watson uses these words:[2]

> "From Cannon's work it is easy to see how under the emotions of rage, fear and pain stimulation the possibility of increased muscular effort might aid the organism in fighting or in flight On the other hand, it is difficult to see how this physiological state plays any serviceable role in adjustment unless the organism is in a situation where the increased muscular possibilities are to be used; but such situations are rare. A man in the army receives a letter telling him that his wife has gone off with another person. The news is undoubtedly a strong stimulus; depression takes place and examination shows the presence of sugar in the urine, and naturally an increased supply in the blood, but his routine of camp activity happens to be such that no great muscular demand is made of him. We may grant Cannon's general position and yet maintain that it is not a very serviceable concept for the ordinary routine of daily life We are no longer living in a frontier country, and outside of an occasional war, there is not much opportunity to bare our teeth and struggle for existence in the good old primitive way of our ancestors Cannon's appeal to the biological serviceableness of the emotional reactions needs modification"

I have made use of this long quotation for the reason that I believe it shows its author laboring under a misconception of exactly the kind into which his behavioristic conception of psychology, from the very nature of things, would lead him. Entirely aside from the question of the adaptive nature of emotional reaction, as a matter of fact the argument here advanced has no bearing at all upon Cannon's theory. Cannon is arguing for biological adptation. Watson attempts to refute this argument by citing a hypothetical case, not of *biological*, but of *social* non-adaptation. The several factors of emotional reaction sustained by the unfortunate soldier *do* fit him to meet the situation as a biological one, and this is all that Cannon would claim for them. On the other hand, they *do not* fit him for the social situation. It would be placing a rather heavy burden upon the doctrine of the adaptive effect of emotional reaction to make it undertake to show that man's instinctive reactions serve to make him better adapted to the complex

[2] Op. cit., p. 222.

and varying situations of civilized life. Biological fitness, so far from always meaning social fitness, very often means quite the reverse. Take the case of a prizefighter, if you please—a man with an overload of the instinct of pugnacity. Suppose him to become converted, using the word in its theological sense, and to enter the ministry. Shall we say, then, that the instinct of pugnacity, with its accompanying emotional reactions, now comes to show itself non-adaptive, because there develops no cheek-turning reflex? Following Watson's argument, we should have to admit that a set of adaptive responses have, as a result of the experience known as conversion, become highly non-adaptive, or even injurious.

The point here, as I see it, is that Watson fails to see, or at least to show that he sees, any difference between a social and a biological situation, or between social and biological adaptation. Are there these two different kinds of situations? My answer is yes. I call one situation the animal situation, the other, the man situation. What, now, is the constituting factor of the difference between them? Watson's error, I think, lies in the fact that from the very nature of his schema, he can admit no such factor, or at least cannot recognize the factor which is operative here. I do not see how the existence of such a differentiating factor can be successfully disproved, and I know of no better name for it than "mind" or "consciousness." For it is precisely what we have known by these terms that constituted the situation to which innate reactions are not adapted

Let me illustrate by another example, which I consider less artificial than the one which I quoted from Watson. Suppose that I am walking down a street, when suddenly I feel a violent blow on the back. If I am of a somewhat irascible temperament, it is not at all unlikely that this will act as a stimulus to set off the emotion of anger, with its characteristic physiological accompaniments, of the nature shown by Cannon, constituting a set of reactions which tend to make of me a more efficient fighting animal. I wheel about, prepared to fight, when I perceive my assailant to be an old friend whom I have not seen for months or years. What then happens to my emotional attitude? The reaction, which up to now has been clearly adaptive, suddenly ceases to be anything of the kind, and a new disposition, quite different in character, takes its place. Why? Because the situation is no longer a biological one, it has become a social situation. True, the physiological effect, meaning the direct effect, of the blow on my back has in no way been modified. A blow on the back is a blow on the back, whether from friend or enemy, but I am no longer responding to it as an animal, I am responding to it as a civilized man,—as a member of society. Or again, injury has been done me, my anger rises, but instead of settling the question in animal fashion, as my native tendencies would lead me to do, I use my reason, as we say, and decide to let the law take its course, or, for professional, social, business, or religious reasons decide to ignore it. In other words, I settle it in man fashion. My higher thought processes gain the ascendancy over my emotional reactions.

Professor Pillsbury[1] makes the suggestion that an emotion may be controlled, at least to some extent, by classifying the situation which calls up the emotional reaction. Stimuli which are capable of being classified in

[1] Pillsbury, W B. "Essentials of Psychology," chap xii "The Fundamentals of Psychology," chap. xiv.

different ways arouse different emotions upon the basis of that classification. For example, a chance remark may be classified as an insult and arouse the emotion of anger, or the same remark, coming from a friend, may be classified as a jest and arouse an emotion of an entirely different sort. In another place[4] I have called this method of emotional control "intellectualization of the situation," meaning by that, in effect, the inhibition of emotional expression by the application of the judgment to the question of the nature of the situation which calls the emotion forth. In other words, it means the recognition of the situation as a social one rather than as being on the biological plane, bringing about a corresponding modification in the nature of the reaction.

All this leads up to another question, more important than all these. That question is: Are we ready to discard the concept of consciousness or mind, or is it necessary to do so? Behaviorism would answer this in the affirmative. Watson substitutes for the term "thought" such terms as "implicit language habits," "laryngeal habits," or "sub-vocal talking."[5] Mental arithmetic is, in his phraseology, "sub-vocal arithmetic." We have long taught the role of the vocal apparatus in verbal-motor imagery. What, therefore, is gained by using such clumsy terms in place of the word "thought," which has a perfectly reputable standing? Not only is "sub-vocal talking" a clumsy term by which to designate the thought processes, it is also inadequate, as Watson himself admits. In many instances, thinking may just as well be styled sub-visual, or sub-auditory, as sub-vocal. In the case of verbal-motor symbolism we are fortunate in having a definite set of organs to which to refer it, but how about visual imagery?

My contention is that in a situation, such as the one in which I am now placed, for instance, while much of my behavior is observable to an external investigator, things are happening which, although definitely observable by me, cannot be made to yield to instrumental verification. They are not the less real for that, however, nor are they explainable, at least in the light of our present knowledge, in physiological terms. When it becomes possible so to account for them, psychology will have ceased to exist. Why is it not possible for me to recognize two phases of behavior, mental and physical, if you please, or two kinds of phenomena, and to decide that I will confine my study to the mental phase, with its attendant phenomena? Why should I be damned as a dualist if I do make such a decision? The philosophical concept of dualism need not enter into my scheme of things at all. Neither is it my business to try to explain the relationship between the two sets of phenomena,—that is a question for the metaphysician,—but so far, I have found a fruitful and interesting field of study in observing phenomena which to me are distinct in type and which are the property of no other science.

Because it expresses my point of view in a way so much better than I could do it for myself, let me use the following quotation from H. J. Marshall:[6]

[4] The Education and Control of the Emotions. "Journal of Educational Psychology," 8.407-415, September, 1917

[5] Loc. cit., pp 14, 322ff.

[6] Marshall, H. J. Behavior. "Journal of Philosophy, Psychology and Scientific Methods," 15:258-261, May 9, 1918.

. . . The biological student is himself a man, and as he observes his own activities, still as a part of the objective world, he discovers in them . . two types of behavior. When in regard to his own body he studies that highly complex form of behavior that is hesitant and not immediate, he finds all that he discovers in connection with his studies of this type of behavior in other animals; but in very many cases **he discovers also something more.** He finds not only behavior of this special type, but 'conscious behavior'"

In this observation of his own behavior the student then has not only the characteristics that yield the special sciences of neurology and bio-chemistry, for instance, but a quite different characteristic that yields the special science of the conscious; and this is what has been designated as psychology."

A little farther on in the same article from which I have just been quoting, I find the following statements, with which I am heartily in accord:

". . It is evidently possible for some man to hold that the consideration of psychology, brought to his notice in the course of his study of behavior, is unimportant and unfruitful, and hence quite unworthy of attention. But it seems to me that if he does so, and rejoices to proclaim such an opinion, he can scarcely expect to find that in the long run his views will be held to be significant. Yet, if I understand the situation, it is just such a view that is held, and openly proclaimed, by Professor John Watson, and by those who follow his lead

This is no occasion to attempt to show that the study of the conscious characteristic of self-observed behavior is important and fruitful and, therefore, fully worthy of attention, as I think it would be quite easy to do I would here merely emphasize the fact that Dr. Watson, in taking the position he holds, while developing the exceedingly valuable objective biological science which is now commonly called 'behaviorism,' is deliberately abandoning the study of psychology altogether; and in asking us to discard the concept of consciousness, and to substitute for it the concept of behavior as the substance of psychology, is dealing with an obfuscation that can not but be deplored."

To my mind, that puts the issue squarely before us. If behaviorism offers the only hope of a scientific psychology, and if we, as psychologists, in order to become men of science, must follow the path which the behaviorists are marking out for us, then I, for one, am content still, for a while at least, to be classed among the metaphysicians.

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GROUPED VERSUS INTERSPERSED METHODS OF READING-RECITATION

BY E. B. SKAGGS.

After varied experiments by many different investigators, ending with the very thorough and excellent work of Gates (Recitation as a Factor in Memorizing, 1917, Archives of Psychology, No. 40), we apparently are entirely warranted in saying that in any learning process, reading plus attempts at recall are better than mere reading alone.

However, the point has remained as a question regarding the grouping or interspersing of these recitations and readings. It is this point that the present little investigation hoped to throw some light upon. Our general plan has been to use two groups of subjects, trained graduate students and untrained undergraduates. In attacking the problem we desired to begin with non-sense syllables and later introduce sense material, as poetry, *e. g.* Our present report is concerned only with the results secured from the use of non-sense material. (Series of 12 syllables each were used.) Our investigation of sense material has just begun and we hope to have it ready in a short time.

Our method of reading and recitation differs somewhat from that used by others, as Witasek and Gates. Their recitation consists in not merely an attempted recall, but also in a reading of that which the subject could not reproduce. This complicates the factors very considerable and we thought it advisable to make a recitation an attempted recall and nothing else. Hence our recitation means that the subject tried to recall all he could and did *not* involve *glancing* at the syllables to supply that which he could not get. Later, for comparison's sake, we hope to use the mixed method with the sense materials.

There were 18 untrained subjects and five trained subjects. There were four methods employed: First, a purely interspersed method of reading and recitation; second, a slightly grouped method (2L 2R 2L 2R, etc); third, an intermediate method (3L 3R 3L 3R, etc.); fourth, an extreme grouped method (6L and 6R). In any method there were thus six readings and six recitations. The material was exposed serially on a modified Wirth memory machine (a screen hiding subject from experimenter) at the rate of one syllable per one and one-fourth second.

The more complete description of the methods, technique, etc., along with tabulated results, will be published later. Here we may briefly summarize the main results and a few interesting incidental results.

In the beginning we took a group of eight untrained subjects and gave them interspersed and extremely grouped methods.[*] Their average, based on four learnings done on a comparable basis, show a striking inferiority of the grouped method, in the amount learned, the hour retention and the 24-hour retention. The comparative averages for the above respectively are as follows:

TABLE I.

Method.	Learned.	Hour.	24 Hours.
Interspersed	10.34	9.18	8.41
Extreme grouped	7.79	6.95	6.10

We now gave three methods to a second group of ten untrained subjects, the above-mentioned methods and in addition an intermediate method. Following are the tabulated end results:

TABLE II.

Method.	Learned.	Hour.	24 Hours.
Interspersed	10.57	9 50	8.95
Intermediate	10.10	9.57	9.09
Grouped	9.30	8.80	7.78

GROUPED VS. INTERSPERSED.

Here the story is the same for the amount learned, but in the hour and 24-hour retention tests the results are about the same for the interspersed and intermediate. However, the figures show clearly that as we come in from the extreme grouped toward the interspersed method the score increases or vice versa.

Our trained subjects give us the most reliable and cleanest cut results. The conditions of the experiment were carried out most carefully with them and they were given a preparatory training in learning non-sense material (learning from ten to twenty-five series [of 12 syllables] before records were kept). Following are the tabulated averages:

TABLE III.

Method I—Interspersed.

Subject.	Amt Learned.	Hour.	24 Hours.
E. B S.	11.70	11.30	9.50
S M.	11.70	11.30	9.00
M. G.	11.30	10.30	7 70
E. I. G.	12.00	11.70	11.30
I. D S.	11.50	11.50	10.30

Method II—Slightly Grouped.

Subject.	Amt. Learned.	Hour.	24 Hours.
E. B S.	10.30	9.30	7.80
M. G.	11.30	10.00	10.00
E. I. G.	11 00	11.30	11.00
I. D. S.	10.75	10.25	9 70

Method III—Intermediate.

Subject.	Amt Learned.	Hour.	24 Hours.
E. B. S.	9.80	9.30	7.70
M. G.	10.30	9 30	8.30
E. I. G.	10.00	9 30	7 50
I. D. S.	9.00	8.50	8.00

Method IV—Extreme Grouped.

Subject.	Amt. Learned.	Hour.	24 Hours.
E. B. S	6.20	6.20	5.20
S. M.	9.50	9.50	7.10
M. G.	9.00	10.00?	7 50
E I. G.	8.00	7.70	6 30
I. D. S.	6.00	5.50	4.75

The results are very striking. If a curve is plotted, showing the average for each subject on each of the four methods for each test interval, we get curves all of one type with the exception of subject M. G., whose curve is rather uncertain.

The above indicates the following principle: Interspersed reading and recitation is the most efficient; as we group more and more the learning efficiency is decreased. The interpretations of these results will be given later.

As an interesting result we find that, comparing ability to learn much with ability to retain well, we secure a correlation of .65, probable error being .078. (Product-moment method used instead of rank method due to number of tie cases.) Due to the small numbers this correlation is not significant but indicates, along with many other investigations, that those who learn much in a given time retain best.

Our curve of forgetting, by our methods of giving and scoring, shows that in one hour very little is forgotten and less than a third in 24 hours.

In the course of the experiment we believe we find evidence of two types of individuals, one who gets and keeps the experience with associative aids stripped to a minimum. We would call these the "mechanical or rote learners." A second group is helpless without some associatory aids. This group we may call "associative learners." Others have reported something of this also. The point needs investigation.

University of Michigan.

THE RELATION BETWEEN THE TRAUBE-HERING AND ATTENTION RHYTHMS.

BY C. H. GRIFFITTS AND EDNA I. GORDON.

The possibility of a casual relation between the Traube-Hering waves and the attention waves was first suggested by different physiologists, and this connection was seemingly established by the work of Slaughter,[1] Taylor,[2] Galloway[3] and Bonser.[4] Slaughter and Bonser reported a direct correspondence between the two rhythms, for some subjects at least. Taylor and Galloway (Mr. Sherman's results) presented data which indicated that, on the whole, stimuli have the same effect on both rhythms. Professor Pillsbury[5] had shown a diurnal rhythm in the attention waves, and Galloway reported a corresponding rhythm in the length of the Traube-Hering waves. Altogether, the evidence seemed conclusive that the overflow effect of the vaso-motor rhythms is a factor in determining the rate of the attention rhythm, although until more is known of the origin and nature of the Traube-Hering rhythm it is possible to question whether in any real sense the Traube-Hering rhythm causes or produces the changes in attention. Since the fatigue of the sensory and of the reinforcing cortical neurones are regarded as factors, it is easy to see how the reinforcement from the vaso-motor center might actually help to produce the attention wave in the case of minimal stimuli; it is not so easy to see how it could do so in the case of binocular rivalry or of ambiguous perspective, providing the subject maintains an impartial attitude toward the two interpretations. The theory would seem to require us to assume that the overflow from the vaso-motor center has a greater reinforcing effect on the relatively less fatigued of the cortical groups of neurons. Here we might have to consider a conflict with Weber's law unless we assume a greater resistance on the part of the more fatigued groups of neurons. The whole question may be complicated by having to consider a possible inhibitory effect at one phase as well as a possible reinforcement at another phase of the circulatory rhythm There also seems to be some difference of opinion as to whether vaso-constriction and vaso-dilation are both active phases, or whether one is active and the other passive; the answer may be different for different parts of the body.

However, this impartial attitude in binocular rivalry and ambiguous perspective is seldom found unless demanded, and perhaps not then, and in the fluctuations of the minimal stimulus and of imagery it might well be, as the evidence seemed to indicate, that the influence of the vasto-motor

[1]Slaughter, J. W., "The Fluctuations of the Attention in Some of Their Physiological Relations," Amer. Jour. of Psych., XII, p. 313.

[2]Taylor, R .W., "The Effects of Certain Stimuli Upon Attention Waves," Amer. Jour. of Psych., XII, p. 335.

[3]Galloway, C E., "The Effect of Stimuli Upon the Length of Traube-Hering Waves," Amer. Jour. of Psych., XV, p. 499.

[4]Bonser, F. G., "A Study of the Relations Between Mental Activity and the Circulation of the Blood," Psych. Rev., p. 120, 1903

[5]Pillsbury, W. B., "Attention Waves as a Means of Measuring Fatigue," Amer. Jour. of Psych., XIV, p. 277.

rhythm might be one of the factors determining the rate of the attention rhythm. Our interest began three years ago when Professor Pillsbury suggested that Slaughter's work be repeated. Various conditions, including the war, prevented anything being done at the time. Later, some contemplated work in another direction made it practically necessary to repeat Slaughter's work, if for no other reason than to determine the truth of Taylor's statement that "The Traube-Hering and other circulatory rhythms can be more conveniently studied in man in their secondary forms as attention changes than directly by the plethysmograph."

Method.

Long kymograph records showing time, in seconds, reactions to attention changes, pneumograph and plethysmograph records were taken. For the plethysmograph record two long rubber bulbs were placed, one on either side of the subject's first two fingers and wrapped. These were connected by a tube with a piston recorder. The arm rested in a wide cloth sling suspended from near the ceiling. The subject was in one room, the apparatus in another. Since Slaughter and Bonser apparently had not considered the possibility of the effect on the circulation of the reaction itself, they used either a bulb to be pressed by the subject, or a telegraph key. In using either the motor situation is quite different in the two phases of the attention rhythm, and it is quite possible that their results are due to this factor alone. Our reaction key was a stick to be moved horizontally, making contact when moved one way, breaking it when moved another. There were no springs, and so while the effects of motor reaction were not eliminated, they were made the same for both phases of the attention rhythm, since there was no necessity of keeping a key pressed down or a bulb compressed during either phase.

The "stimuli" used included imagery, minimal light, binocular rivalry, and ambiguous perspective. For control experiments the minmal light was turned on or off, the subject reacting as to the genuine fluctuations of attention.

Summary of Results.

1. On the whole there was but a slight correlation between the attention and Traube-Hering rhythms, yet the ratios show a tendency for appearances to occur during the trough and upward slope of the Traube-Hering rhythm, and for the disappearances to occur during the crest and downward slope. These results accord with the result reported by Slaughter and Bonser.

The control series, however, show exactly the same relationship.

2. At times, in the control experiments, particularly when the changes were sudden and the light (a 2-volt lamp, 12 feet in front of the subject) fairly bright, what appeared to be the true Traube-Hering waves became synchronous with the rhythm of the changing of the light. But whether or not these are Traube-Hering waves or merely the vaso-motor effects of the changes in attention and the motor reactions as the light changed, the results of Slaughter and Bonser can no longer be regarded as evidence that the Traube-Hering rhythm is a factor in producing the attention rhythm.

3. With one subject the breathing was either short (about 3 to 3.5 seconds), or as long as the Traube-Hering rhythm (8 to 10 seconds). In the

latter case the two rhythms were almost exactly synchronous. In some cases the attention rhythms became synchronous with these other two rhythms. In such cases the appearances (imagery or minimal light) tend to appear at or just past the crest, and the disappearances to occur before the trough of the same wave. Care must be taken in drawing deductions from this effect.

4. The slight relation between the Traube-Hering and attention rhythms might also be explained as due to the vaso-motor effect of the changes in attention and of the motor reactions, super-imposed upon the Traube-Hering waves. The records offer evidence for this.

5. When the attention and Traube-Hering rhythms of different subjects are compared, the person with the longer Traube-Hering may have the shorter attention rhythms and vice versa. There seems to be no correlation between the lengths of the two rhythms.

6. No correlation between the lengths of the two rhythms was found when all the records of one subject were compared.

7. Our results may not disprove the theory that the attention rhythm is in part the result of the Traube-Hering rhythm; it does, however, leave the theory with little definite experimental evidence in its favor.

University of Michigan

A STUDY OF DISTRACTION.

ADELBERT FORD.

The description of the experiment which I am going to submit for your approval is not complete. I cannot go into it deeply in the time which I am allowed. And the results I am going to outline are tentative. I expect to publish well co-ordinated data at some later time.

We are all familiar with the notices in the reading rooms of libraries warning people to be as noiseless as possible. There aeems to be in these notices a tacit assumption that noise will be detrimental to efficient mental work. Many people openly avow their dislike of reading or studying under distracting conditions.

A few years ago Dr. Morgan of Columbia University made an extensive study of the effects of loud noise distractions upon voluntary attention. Contrary to the ordinary supposition, he found that his subjects actually did faster work under noise distraction than during quiet, with no appreciable decrease in efficiency, although he admitted that the nervous tension was much higher during the noise distraction and as a result the rapid mental work was probably accompanied by early fatigue.

Briefly, Dr. Morgan's experiment consisted in a test of the subject's ability to work a series of code-problems while various bells, buzzers and noise-making devices were thrown on as the subject was trying to work. Dr. Morgan averaged the time taken to work a series of problems during distraction and compared this with the time taken to work a similar series of code-problems during quiet intervals. The comparison was made by the use of the Pearson coefficient of correlation. The answers to each problem were made by pressing certain keys controlling Marey tombours which registered the amount of pressure exerted. There proved to be an excessive amount of pressure during the distraction periods and this gave Dr. Morgan his conclusion that the speed during the distraction period was a resultant of extra nervous energy.

Now, Dr. Morgan's report seems to show that he used the finest sort of laboratory technique. His apparatus was admirably made. But I do wish to draw exception to his method of computing data. It is for this reason that I have started to work upon a very similar problem.

We must recognize that there are two kinds of attention involved in this sort of an experiment: Voluntary attention to the problem at hand, an attention which is a cultural product and the result of social pressure; and involuntary attention which is not desired by the subject, but which, because of the sensory stimulus, forces itself upon the consciousness. It is generally recognized that one of the conditions of involuntary attention is change and novelty. A new stimulus at first arrests the attention, but if it is continued for a time the attention can be wrested away and there gradually comes a certain amount of heedlessness to the stimulus. For this same reason, when the distraction stops the sudden change again attracts

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the attention just as surely as the first appearance of the original noise. It is fort this reason that I should expect that the time necessary to work the first problem should be much longer than it was for the quiet period, and I should expect that as the subject works on under the distraction each problem can be worked quicker than the previous one. It can be readily seen that, as Dr. Morgsn averaged ten problems together, it might be very possible that he covered up what is the most important thing of all—the time length to work the first problem. It can also be said that sudden quiet, because of the change or condition of novelty, might be considered quite as much of a distraction.

In order to test out this idea, and also in order to discover other psychological accompaniments of attention, I have set up the following apparatus in the laboratories of this university:

I arranged a series of arithmetical problems consisting of the multiplication of a two digit number by a single digit number, making the problems as nearly as possible of equal difficulty by selecting only those numbers which involved carrying over an addition to the tens digit. The problems are worked mentally and the answer written with a pencil from left to right on a strip of paper which winds up a small distance on a reel after each problem is worked. The board under the pencil point is supported by a stiff spring which gives slightly each time the subject writes and makes a record on a smoked-paper kymograph of the amount of pressure exerted by the pencil point. I am using a pneumograph connected with a Marey tambour for taking a respiration record, apparatus similar to that used by Dr. Morgan. When the subject has done one problem he moves, by means of a foot-trip, the tape on which the problems are presented. For timing devices I am using two instruments, one a mercury contact clock which marks full seconds on the smoked paper, and an electrically controlled, vibrating steel tongue which marks tenths of a second. The time taken to work each problem is measured to a tenth of a second. In addition to this I am measuring the blood circulation by means of a standard Pillsbury-Lombard piston recorder.

Such tentative results as I have obtained are as follows: When I average ten reactions together I get the same result that Dr. Morgan got. But the time reaction for the first problem is, as might be expected, very much longer, indicating that the distraction, which consisted of a bell and a buzzer, had its principle effect at the beginning. After the first two or three problems the subject is able to work just as fast, or even faster, than ever. This shows that after the first two or three problems, or after the first ten or fifteen seconds, the bell and buzzer *are no longer a distraction.* Looking at it from this light it is unfair to say that the subject can worker faster under distraction, because he is no longer being distracted. As soon as the quiet period begins there is a great increase in the time necessary to work the first problem, showing that the sudden quiet is also a distraction. Following this I then get another rapid decrease in the reaction times. I have also arranged a series of distractions of a varied character such as to present a continuous series of changes and prevent monotony. This is what I would call a real continuous distraction because it continues to distract, whereas the bell and buzzer ringing continuously only distract when they are first sounded. The average time reaction for this alternating distraction is much

higher than average for quiet periods showing that real distraction slows up the worker. The shorter time obtained by Dr. Morgan was due to the purpose-in-mind established when the subject felt that he was obliged to put in a greater effort.

I am also finding some evidence of a greater inaccuracy in working the problems during the distraction. My work with the writing pressure board has brought so far exactly the same results as Dr. Morgan found with his key-pressure apparatus. There is an excessive amount of energy in the muscular contractions during distraction periods But this extra pressure, I think, may be traced to the extra exertion on the part of the subject who feels that he must work faster during this period.

The use of the plethismographic piston recorder with the experiment has produced some very positive results. I have found that there seems to be a tendency for vaso-constriction to occur in the arterial walls at the beginning of each attention period. With a large number of the subjects I found a vaso-constriction during the slight pause between problems and a vaso-dilation accompanying each problem, making a full one-to-one correspondence between waves in the pulse line and each problem. I was criticised for this on the ground that my one-to-one correspondence was caused by the muscular action used in writing and in operating the foot trip. Because of this criticism I operated several control experiments to determine whether the correspondence was caused by muscular action or by actual mental changes.

In order to show you the basis of my control experiments, I will first say something of some other work that has been done on the relation of circulatory changes in attention. Slaughter asserted that the Traube-Hering rhythmic curve in the pulse line could be used as a measurment of the attention unit of any individual where that attention unit was measured by the "fluctuation of attention" phenomenon. Because the length of the units in "fluctuation of attention" varies with the kind of a device used, it is manifestly false to assert that any one of these devices is a true measurement of the attention unit. With minimal light stimuli Slaughter did get a rough correspondence, and it seems that the correspondence was made the basis of the theory that attention changes were caused by certain emanated energies which caused both fluctuation of attention and the Traube-Hering wave.

In my control experiments I had the subject sit absolutely quietly and read a magazine selection. At intervals of ten seconds each I turned out the electric light which illuminated the page and left him in enough darkness to prevent being able to read, but enough light to keep his place on the printed line. The result was, of course, arrested attention every ten seconds. This subject's Traube-Hering wave during rest moments varied from seven to fifteen seconds in length. When I turned out the light once in every ten seconds, and left it out for about three seconds, there came a direct one-to-one correspondence between the Traube-Hering curve and the reading periods. If I changed the reading periods to as much as twelve seconds, or as little as eight seconds, I still got the correspondence, which was *perfect*. This shows that the Traube-Hering wave can be pulled one way or another by mental rhythms. There was absolutely no voluntary physical action in this control experiment. This is my answer to the criti-

cism that my correspondences were caused by physical action. I found other cases where a slow breathing rate pulled the Traube-Hering wave into a direct correspondence. There is no reason why there shouldn't be other bodily rhythms which could influence the Traube-Hering wave into a direct correspondence. I am conscious that some will say at this stage of the experiment that I have no longer a true Traube-Hering wave; that the Traube-Hering rhythm has been covered up. I will not argue this question here but will simply say that if the units of attention are long enough there results a direct correspondence between a wave in the pulse line and the attention units, and that this correspondence shows that the pulse waves are not stable, but can be pulled one way or another by the other mental or physical rhythms. Dr. Griffitts, who worked in this laboratory, found the same principles to apply.

I wish to warn against any assumption that all and every one of my records show this direct correspondence. They do not. In some cases the problems were worked so rapidly that the attention rate completely broke away from the Traube-Hering rate and there was no longer a correspondence of any kind. It is only when two rhythms are nearly the same rate that the correspondence starts. It may be likened to two tuning forks which, separately, vibrate at slightly different rates but, when placed near each other, begin to vibrate in exact unison. In a few records I found small notches corresponding to the attention rhythm superimposed upon the Traube-Hering rhythm. There are only a few records like this In one or two cases I found notches caused by the respiration rhythm superimposed upon the waves caused by the attention rhythm. In such cases as this the line usually gets so much broken up that analysis of the correspondence becomes nearly impossible. Out of all these data on correspondence, the one most prominent feature to be noted is that there are actually changes in the blood supply that have a direct correspondence with mental changes.

There has been suggested by Robbins of the Boston Stammerers' Institute the idea that emotional shocks are accompanied by vaso-constriction in the periphery and that his students were unable to pronounce their words until these shocks had disappeared, or at least until the vaso-constriction has disappeared. If such were the case it would seem that the first effect of a distraction ought to produce a similar shock which would be responsible for the greater length of time required for working the first problem after the distraction had begun. This sounds like a nice theory, but it refused to work for me. On introspection nearly all confessed to emotional disturbance, and the respiration line added evidence to this. Some of the subjects were so startled that they gave visible physical signs. Yet in these cases only a very few showed the vaso-constriction supposed to accompany emotional shock. And in case there was the vaso-constriction with the emotional outbreak, there was no noticeable increase in the time length required for working the first problem over that found in other records. This seems to show that the plethismograph is not adapted for measuring shock, at least as far as it applies to my experiment.

On the whole I think I can say that distraction is not conducive of mental work, either in speed or efficiency, and there is certainly a greater expenditure of muscular energy accompanying the motor reactions. In addition to this I think I have found considerable evidence that an artificial at-

tention rhythm is capable under certain conditions of pulling the Traube-Hering wave, or whatever wave you may call it, into an absolute conformity. And it seems to me that some of these conclusions may be found of great importance to further work on the practical applications of the laws of attention, and the physical concomitants of mental activity.

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THE PLEISTOCENE LOCALITY AT WAILES BLUFF, MD, AND ITS MOLLUSCAN FAUNA.

BY E. R. SMITH.

In the year 1830, Timothy A. Conrad, that father of American Tertiary Invertebrate Paleontology, read a paper before the Philadelphia Academy of Natural Sciences on the Pleistocene locality at Wailes Bluff, just above the mouth of the Potomac river, St. Mary's county, Md. Since that date, many American paleontologists and geologists have visited this easily accessible locality and have published lists of the fossils and discussions of the significance of its fauna The most important of these was contained in the Monograph on the Pliocene and Pleistocene of Maryland published by the Maryland Geological Survey in 1906. In the summers of 1914 and 1915, parties of students under the leadership of Professor G. D. Harris of Cornell University made two brief stops at Wailes Bluff. They were but incidents in trips of over 2,500 miles each in Professor Harris' cabin-cruiser Ecphora. The material, collected at this time largely in bulk and later carefully washed and sorted, has been made the subject of study for this paper.

To describe the locality, one can hardly improve upon the following original description by Mr. Conrad:

"About three miles north of the low sandy point which forms the southern extremity of the peninsula, the bank of the Potomac rises to an elevation of about fifteen feet at its highest point; the fossils are visible in this bank to the extent of a quarter of a mile. The inferior stratum is a lead-colored clay, containing vast numbers of the (*Mulinia*) *lateralis* of Say, which, in many instances, appear in nearly vertical veins as though they had fallen into fissures. The (*Barnea*) *costata* is also numerous, and each individual remains in the position in which the living shell is usually buried in the sand or mud; that is, vertical, with the posterior or short side pointing downwards; they are so fragile, that they can rarely be taken entire from the matrix. Upon this stratum of clay, in a matrix of sand, lies a bed of the *Ostrea virginiana*, in some places a foot in thickness. It is nearly horizontal; in some places at least eight or ten and in others not more than four feet above high water mark."

In more detail, the section as exposed at present is as follows:

Langley's Bluff, St. Mary's county, exposes a section, in some ways, of greater interest. There the Pleistocene overlies unconformably the fossiliferous St. Mary's Miocene with a zone of mixed Miocene and Pleistocene fossils between the distinct faunal zones. The Wailes Bluff fauna, small as it is, as compared with some others on the Atlantic coastal plain, for example, Simmons Bluff, S. C., is considerably larger than that at Langley's Bluff. For this reason, it is made the subject of this brief report. An effort has been made to include every species ever reported on good authority from Wailes Bluff.

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TABLE I.

				Ft.
	Nonfoss. Beds.	Sandy loam		1±
		Gravelly sandy loam		2±
		Cross-bedded sand and gravel		3±
Talbot substage	Foss. Beds.	**Ostrea** Bed	Sandy clay with great numbers of gigantic **Ostrea virginica** Gmelin, with which are associated **Mytilus hamatus** Say, **Mya arenaria** L. and **Crepidula fornicata** L. The **Mya** becomes much more abundant toward the top	1±
		Venus Bed.	Blue-gray clay with large numbers of **Venus mercenaria** L., accompanied by the fauna of the **Mulinia** bed	0-1
		Rangia Bed.	Blue-gray clay with the fauna of the **Mulinia** bed, but with marked concentration of considerably worn valves of **Rangia cuneata** (Gray), no specimens found showing the two valves together in position as in life	0-1
		Mulinia Bed	The main fossil-bearing bed, a lead-colored, very sticky clay, carrying the complete fauna The large numbers of **Mulinia lateralis** (Say) are characteristic The appearance of fissures filled with shells is due to borings of **Barnea costata** (L.), which in places are completely filled with the smaller species of shells. Well-preserved specimens of **Busycon caricum** (Gmelin) are also prominent features of this bed	0-6

The species of the family Pyramidellidae are being studied by Dr. Paul Bartsch of the U. S. National Museum and will be described in one of the publications of that museum. Combining the specimens sent him by the present writer with those in the National Museum and the museums of Johns Hopkins University, the Maryland Geological Survey, the Philadelphia Academy and various other sources, he has found a wealth of hitherto unknown species in this family of minute Gastropoda. He considers that there are sixty-three species in this one family in the Wailes Bluff fauna, of which sixty-two are new. The one species hitherto described *Odostomia* (*Chrysallida*) *melanoides*, was described by Conrad from this very locality, with a list of St. Mary's Miocene new species. Later writers, even Conrad himself in later works, considered this as a Miocene species. Clark, in the Monograph on the Pliocene and Pleistocene of Maryland, states as follows: "This species [*Odostomia* (*Chrysallida*) *seminuda* (C. B. Adams)] is very closely related to, if not identical with, *O. melanoides* (Conrad), described in 1830 from the Miocene." However, reference to the original article will prove that Wailes Bluff is the type locality for this minute form, assuring its typical Pleistocene form here.

The systematic arrangement follows the American revised translation of Zittel's "Textbook of Paleontology." The source of material aside from the writer's collections are given in a list appended to this article. In the discussion of evidences of climate, depth of water, etc., the Pyramidellidae

will, of necessity, be disregarded. In the fauna, there are twenty-eight species of Pelecypoda and twenty-two species of Gastropoda. Of these, twelve species have not been reported before from Walles Bluff. Fourteen of the species begin in the Miocene; twenty in the Pliocene; and sixteen in the Pleistocene. With but one exception, *Callocardia* (*Agriopoma*) *sayana* (Conrad), referred by Dall to this locality, all species are found living on our eastern coast. This fixes beyond doubt the Pleistocene age of the deposit

During Pleistocene time, a considerable number of the species had wide distribution along our east coast. Wilson reports eighteen of the same species from Sankaty Head, Mass.; the writer has collected thirty-eight of the same species from the Neuse river, below New Bern, N. C., and thirty-seven from Simmons Bluff, S. C.; Dall reports ten of these species from North Creek, Osprey, Fla. All of these deposits are of undoubted Pleistocene age with the exception of that on the Neuse river. In the opinion of the writer that deposit also is of Pleistocene age. A later study will take up that very interesting locality with certain other notes on the Upper Tertiary and Pleistocene history of the lower Neuse river basin.

In the recent fauna, Henderson and Bartsch report a list of thirty-eight Pelecypoda and forty-five Gastropoda from Chincoteague Island, Va. Of these, thirty-four are found at Walles Bluff, showing similarity in the faunas. Only five of the Walles Bluff species do not have a recent distribution farther north than Maryland. Seven go no farther south than Cape Hatteras. This mixture of faunas is not due to distinct beds as at Sankaty Head, Mass., where the lower faunas are of southerly affinities and the upper faunas of northerly affinities. The most remarkable instance of a southern form in the beds is *Rangia cuneata* (Gray). Although we cannot accept as a whole Conrad's conclusions regarding its Pleistocene distribution, his remarks on this subject in the Proceedings of the National Institution are of exceeding interest. He wrote as follows:

"I have before alluded to the peculiar and highly important distribution of the existing (*Rangia*), burrowing in myriads in the mud flats near Mobile, and confined to the estuaries of the Gulf of Mexico. An occasional water-worn valve in the deposit on the Potomac, above described (Walles Bluff), seemed to indicate that the species lived in that river in the upper Tertiary (Pleistocene) period. This conjecture was converted into certainty by an exploration of the shore farther north, which resulted in discovering a bed composed exclusively of the *Rangia* on the land of Mr. Ebb, above the mouth of St. Mary's river. This bed, except that the shells are smaller, is precisely the same as those which line the bay shore near Mobile. The valves of the shells are frequently connected and there can be no doubt that here was the spot where they lived and were embedded; that this was a region of sand flats bared at low tide, the water brackish, as it is now, and that the deposit near the mouth of the Potomac was of the same period, but more directly connecting with the ocean." His further conclusions that climatic conditions in the Chesapeake Bay of this bit of Pleistocene time was much the same as that of the gulf today are not supported by the other evidence. The very considerable admixture of northern forms forces the conclusion that conditions were not far different from those existing today at that latitude.

The water was certainly almost of the salinity of the present exposed portions of the Chesapeake Bay. It was shallow, as shown by the figures of depth given in the last column of the chart. It was not a sea exposed to great waves. Such fine, sticky clay could not have been laid down in shallow water agitated by the waves of the open ocean.

In conclusion, I may well quote further from that rare Conrad paper in the Proceedings of the National Institution:

"Deep harbors and bays seem to have been filled up by the very gradual accumulation of fine silt or mud; generations of shells were entombed in frequent succession, until the harbors, bays, or part of the ocean itself shrinking into shallow lagoons, no longer furnished the conditions necessary to their increase, and myriads of oysters took possession of the deserted beds. There is no pause, no interruption to this ceaseless mutability. Our harbors and our bays must, in the lapse of ages, be filled up by the unfailing influx of silt; our present beds of oysters be converted into dry banks of shells. New bays will succeed to those which we now behold; and other lagoons will encroach upon the sea. Whoever attentively examines the locality last described (Wailes Bluff) on the Potomac river, will be forcibly reminded of the mutability of the present features of our earth: he can read distinctly the history of the past, and anticipate, in a measure, the annals of futurity, the new order of things, the relative condition of sea and land yet to be, long after he has passed away, and his name, his influence, his labors having left no more trace of his existence than the baseless fabric of a vision."

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WAILES BLUFF MOLLUSCA.

GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION.

PELECYPODA.

SPECIES.	GEOLOGICAL RANGE.		PLEISTOCENE DISTRIBUTION. Wailes Bluff, Maryland.*	Sankaty Head, Massachusetts.	Neuse River, North Carolina.	Simmons Bluff, South Carolina.	North Creek, Florida.	RECENT DISTRIBUTION. NORTHERN LIMIT.	Chincoteague Island, Virginia.	SOUTHERN LIMIT.	Range in Depth, Fathoms.
Nucula proxima Say truncula Dall	Miocene	Recent	f. c.		x	x		Nova Scotia	x	Florida	2/100
Leda acuta (Conrad)	Miocene	Recent	f. c.		x	x		Rhode Island	x	Mexico	7/236
Yoldia limatula (Say)	Pliocene	Recent	u. c.		x	x		Norway	x	North Carolina	2/60
Arca (Noetia) ponderosa Say	Pleist	Recent	f. c.	x	x	x		Cape Cod	x	Yucatan	Shallow water
Arca (Scapharca) transversa Say	Pliocene	Recent	c.	x	x	x	x	Cape Cod	x	Mexico	2/10
Ostrea virginica Gmelin	Pliocene	Recent	v. c.	x	x	x	x	New Hampshire	x	Mexico	Shallow water
Unio complanatus (Solander) Dillwyn	Pleist	Recent	r.					Maine		Mississippi	Fresh water
Mytilus (Hormomya) hamatus Say	Pliocene	Recent	c.		x			Rhode Island		Costa Rica	Shallow water
Pandora (Clidiophora) gouldiana Dall	Pleist.	Recent	r.		x			Nova Scotia		Virginia	0/30
Divaricella quadrisulcata d'Orb.	Mio	Recent	r.		x	x		Massachusetts		Trinidad	6/50
Aligena elevata (Stimpson)	Pleist	Recent	r.					Maine		Hatteras	2/63
Rochefortia planulata (Stimpson)	Plio	Recent	r.		x	x		Maine		Hatteras	1/15
Callocardia (Agriopoma) morrhuana (Linsley)	Mio.	Recent	r.		x			Prince Edward Island	x	Hatteras	2/10
Callocardia (Agriopoma) sayana (Conrad)	Mio.	Pleist	r.								
Venus mercenaria Linne	Mio	Recent	c.	x	x	x		Nova Scotia	x	Yucatan	Shallow water
Gemma gemma Totten	Pleist	Recent	r.	x				Labrador		New York	Shallow water
Petricola pholadiformis Lamarck	Pleist.	Recent	r.	x	x	x		Prince Edward Island	x	Nicaragua	Shallow water
Tellina (Angulus) tenera Say	Pleist	Recent	u. c.		x	x		Cape Gaspe	x	Barbadoes	0/80
Macoma calcarea Gmelin	Pleist	Recent	r.					Arctic Seas		Long Island Sound	2/100
Macoma balthica Linne	Pleist	Recent	r.					Arctic Seas		South Carolina	Shallow water
Cumingia tellinoides (Conrad)	Pleist.	Recent	r.	x	x	x		Prince Edward Island		Florida	0/50
Tagelus gibbus (Spengler)	Mio	Recent	f. c.		x	x		Cape Cod	x	Brazil	Shallow water
Ensis directus (Conrad)	Mio	Recent	u. c.	x	x	x		Labrador		Florida	0/25
Mulinia lateralis (Say)	Mio	Recent	u. c.		x	x	x	New Brunswick	x	Texas	1/15
Rangia cuneata (Gray)	Plio.	Recent	a		x	x		Alabama Gulf Coast		Vera Cruz	Brackish water
Mya arenaria (Linne)	Mio	Recent	c.	x	x	x		Arctic Seas	x	South Carolina	0/40
Corbula contracta Say	Plio	Recent	c.	x	x	x		Cape Cod	x	Jamaica	3/63
Barnea (Scobina) costata (Linne)	Plio.	Recent	c			x		Cape Cod	x	South America	Shallow water

GASTROPODA.

SPECIES.	GEOLOGICAL RANGE.		Wailes Bluff, Maryland.*	Sankaty Head, Massachusetts.	Neuse River, North Carolina.	Simmons Bluff, South Carolina.	North Creek, Florida.	NORTHERN LIMIT.	Chincoteague Island, Virginia.	SOUTHERN LIMIT.	Range in Depth, Fathoms.
Teinostoma cryptospira (Verrill)	Pleist	Recent	r.				x	North Carolina		Florida	30/150
Epitonium lineatum (Say)	Plio.	Recent	r.		x	x		Cape Cod	x	Texas	Shallow water
Epitonium Humphreysii (Kiener)	Plio.	Recent	r.		x	x		Connecticut	x	Texas	Shallow water
Epitonium denticulatum (Sby.)	Pleist.	Recent	r.					Hatteras		Bahamas	Shallow water
Epitonium multistriatum (Say)	Plio.	Recent	u. c.		x	x		Cape Cod	x	South Carolina	Shallow water
Epitonium cf. Samanae (d'Orb.)	Pleist	Recent	r.							West Indies	
Epitonium sp	Pleist		r.								
Pyramidella (Sulcorinella) n. sp.	Pleist		r.								
Turbonilla (Chemnitzia) n. sp	Pleist		r.								
Turbonilla (Strioturbonilla) n. sp	Pleist		r.								
Turbonilla (Pyrgiscus) 36 n. sp.	Pleist.		r.								
Turbonilla (Mormula) 12 n. sp.	Pleist.		r.								
Turbonilla (Bartschella) n. sp	Pleist		r.								
Odostomia (Chrysallida) melanoides (Con.)	Pleist		r.								
Odostomia (Chrysallida) n. sp	Pleist.		r.								
Odostomia (Menestho) n. sp	Pleist		r.								
Odostomia (Evalea) 8 n. sp.	Pleist		r.								
Crepidula fornicata (Linne)	Mio.	Recent	c.	x	x	x		Prince Edward Island		South America	0/15
Crepidula convexa Say	Plio	Recent	f. c.	x		x	x	Nova Scotia	x	Texas	0/22
Crepidula plana Say	Mio.	Recent	f. c.	x	x	x	x	Prince Edward Island	x	Trinidad	0/147
Polynices (Neverita) duplicatus (Say)	Plio.	Recent	c.	x	x	x	x	Massachusetts	x	Vera Cruz	Shallow water
Triphora perversa (Linne) nigrocincta (C.B.A.)	Plio	Recent	r.		x	x		Massachusetts	x	Antilles	0/30
Columbella (Astyris) lunata (Say)	Plio	Recent	c.	x	x	x	x	Maine	x	Florida	0/12
Alectrion (Tritia) trivittata (Say)	Pleist.	Recent	f. c.		x	x		Nova Scotia	x	Florida	1/40
Alectrion (Ilyanassa) obsoleta (Say)	Pleist	Recent	f. c.	x	x	x		Nova Scotia	x	Florida	Shallow water
Busycon canaliculatum (Linne)	Plio.	Recent	f. c.		x	x		Cape Cod	x	Gulf of Mexico	Shallow water
Busycon caricum (Gmelin)	Plio	Recent	f. c.		x	x		Cape Cod	x	West Indies	0/10
Eupleura caudata (Say)	Plio.	Recent	f. c.	x	x	x		Cape Cod	x	Florida	1/3
Urosalpinx cinereus (Say)	Plio	Recent	u. c.	x	x	x		Nova Scotia	x	Florida	0/10
Terebra (Oxymeria) dislocata (Say)	Mio.	Recent	r.		x	x	x	Maryland	x	Venezuela	Shallow water
Mangilia cerina Kurtz & Stimpson	Mio.	Recent	u. c.		x	x		Cape Cod	x	Florida	3/10
Acteocina canaliculata (Say)	Plio.	Recent	c.		x	x	x	Maine	x	Gulf of Mexico	0/63

*r., u. c., f. c., c., v. c. represent a series of increasing abundance of individuals of a species.

STUDIES ON THE SHORE LINES OF THE SAGINAW BASIN.[1]
(Abstract.)

BY FRANK LEVERETT.

In a paper presented before this academy two years ago, entitled "Drainage Features and Uplift of Shore Lines in the Elsie and Perrinton Quadrangles," the writer gave results of studies bearing on the time of the uplift of the shore lines and evidence as to which of them were affected by the northward differential uplift. It was shown that in these quadrangles the beaches of Lake Saginaw and Lake Arkona were affected by that uplift, but the beach of Lake Warren was not thus uplifted here, though it has suffered uplift in districts farther north. Thus the area affected by uplift had become reduced at the south at the time of the later glacial lake stages. This was a condition that had previously been worked out by F. B. Taylor and the present writer in the part of the shores of the glacial lakes bordering the St. Clair basin and south part of the Huron basin, and brought to notice in Monograph 53, U. S. Geological Survey.

In the field work of 1919 the present writer continued the mapping of the glacial and lake features over several quadrangles in the Saginaw basin which had been covered by glacial lakes, namely, the Chesaning, St. Charles, Saginaw, and Bay City quadrangles, and over the part of the Burt and Flint quadrangles which were covered by glacial lakes. This broader field gave opportunity to determine the direction as well as the time of uplift in the south part of the Saginaw basin. It was found that on the east side of this basin the Warren shore line has been unaffected by uplift about as far north as the north end of the Flint quadrangle, but that northward from there it is uplifted.

It was found that the direction of the tilt line of the Saginaw and Arkona beaches is more nearly northward in this southern part of the Saginaw basin than in the neighboring southern part of the Huron basin, the direction being not more than 10 degrees east of north in the Saginaw basin, while it is about north-northeast in the Huron basin. The direction of the tilt line in the Michigan basin is about 10 degrees east of north. The Saginaw basin thus shows a closer relation to the Michigan basin than to the Huron basin in the direction of tilting. The cause for this divergence in the tilt lines remains to be determined.

Ann Arbor, Mich.

RESULTS OF GLACIAL STUDIES IN THE NORTHERN PENINSULA OF MICHIGAN IN 1919.[1] (Abstract.)

BY FRANK LEVERETT.

About a month was spent in field work in 1919 in Menominee and southwestern Delta counties, and a week in the eastern end of the northern pen-

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insula, in all of which the present writer was assisted by Ralph W. Peterson from the Michigan Agricultural College.

The work in Menominee and Delta counties was directed to the determination of the distribution and extent of swamp land as well as classification of the dry or cultivated lands. Much land that had been classed as swamp in the plats of the Linear Land Survey has been rendered tillable by merely removing obstructions such as fallen trees and beaver dams which had prevented the escape of the water. The distribution of the drumlins and eskers was also worked out, especial attention being given to eskers, since they are valuable sources for road material. The drumlin district was found to be more extensive than hitherto represented, its western limits being near the Sturgeon river in eastern Dickinson county, and near Menominee river where that stream forms the border of Menominee county. A few drumlins are present in Marinette county, Wisconsin, west of the river.

Attention was directed to the degree of weathering and alteration and evidence of age in the drift of the drumlins compared with the drift in the moraines, for Russell in his reports published in the Annual Reports for 1904 and 1906 of the Michigan Geological Survey, had referred the drift of the drumlins to an earlier ice movement than that which produced the moraines. He cited the occurrence of copper and iron ores which had been brought in from the northwest as evidence that the drift in the drumlins was deposited by a southeastward ice movement, while the drift in the moraines and the shaping of the drumlins into their peculiar form are evidently due to a southwestward ice movement. The studies in 1919, however, failed to bring out any evidence that the drift of the drumlins is markedly older than that of the moraines, its aspect being fresh in both classes of drift. The presence of drift copper and iron ores is probably due to gathering up from older drift and redeposition in the drift of the last or Wisconsin stage of glaciation.

In Menominee and Delta counties the limits of Lake Algonquin were determined with more accuracy than hitherto, and this is also the case at points farther east in the peninsula.

On Drummond Island a few drumlinoid ridges were found in a low-lying area of poorly drained clayey drift in the northeast part of the island. These drumlins, and also striae on ledges near them, three miles east of Drummond village, have a nearly north to south trend and are directed toward a belt of thick drift which runs from east to west across the middle part of the island In this there are basins and small lakes and a gently undulating till. These features all favor the view that the strip of relatively thick drift is a morainic belt. The altitude of its highest points is far below the level of Lake Algonquin, so the drift appears to have been laid down in the waters of that lake. It is therefore not surprising that there is not stronger morainic expression, for as a rule the waterlaid moraines are almost featureless smooth ridges.

Ann Arbor, Mich.

SYMPOSIUM ON ZOOLOGICAL TEACHING AND RESEARCH IN MICHIGAN.

1. THE UNIVERSITY OF MICHIGAN BIOLOGICAL STATION AT DOUGLAS LAKE, MICH

BY GEORGE R. LA RUE.

Since its establishment in 1909 on the shores of Douglas lake in Cheboygan county the Biological Station of the University of Michigan has served a dual function, namely, the giving of instruction and the prosecution of research in biology. These two functions will be discussed separately.

The instruction given has been distinctly different in character from the usual university courses in zoology and botany At no time in the history of the station have the stereotyped laboratory or lecture courses of the university been transferred to the Biological Station. In the place of the stereotyped courses there have been developed courses which use the field, forest, lake and stream as the laboratory. Plants and animals are studied in their native habitats and under field conditions. Exercises in the field are as carefully planned, supervised, and directed as in the usual laboratory course. When the problem demands it work is also done in the laboratory and library. Even plant anatomy which is usually considered to have little or nothing in common with field courses, and consequently to have no place in the curriculum of a biological station, has been so developed that it is used as a means of discovering the modifications which fit the plant to its environment. In this manner the course furnishes data to be used in connection with the study of the ecological relations of plants.

It is true that certain courses given at the Biological Station, namely, Systematic Botany, Plant Ecology, Entomology, Ecology of Invertebrates, and certain phases of systematic zoology are given at the universities, and thus there may be some grounds for the claim that to a certain extent the courses given at the Biological Station duplicate those given at the universities. In title and, to a limited extent, in materials used there is some duplication; but in viewpoint imparted, in the kinds of contacts established with plants and animals, in the breadth of knowledge gained concerning the inter-relations of organisms the Biological Station has a great advantage over the universities.

In most universities and colleges animals and plants must necessarily (usually) be studied dead in the laboratory, or living organisms are studied under unnatural conditions, and no adequate idea of the organism as a living thing may be gained; nor can its habitat be reconstructed, or its place in an association studied and defined. The contacts with animals and plants in the usual laboratory are all too brief to permit the gaining of well-defined ideas concerning them; distractions are too numerous, and outside interests too pressing to allow the student leisure, to think. He swallows, but too often does not digest, the mental pabulum offered. The stu-

22d Mich. Acad. Sci. Rept., 1920.

dent at the Biological Station during his stay there lives in a medium of biology; he is immersed in it during all his hours awake. At the university he plunges in two, three, four times a week for an interval of one to four hours, rarely more, then with the towel of social distractions he carefully wipes himself free of the biological medium until the next plunge a day or two later. The all-day soak is more effective than the brief plunge as a means of taking up biological ideas.

The Biological Station has a good deal to offer in the way of courses, methods of study, viewpoints, and contacts. It does not aim to supplant, but to supplement, the biological teaching at the universities and colleges, offering only such types of work as can be handled well with the facilities of the station and with the biota of the region, and avoiding those which can only be handled properly with considerable laboratory equipment. The value of the instruction given is attested by the product in capable, interested, interesting teachers of the newer biology, and in investigators who have been influenced by their instruction and study at the station.

The research has been limited as to quantity by a number of factors, among which might be mentioned the small number of investigators during the early years of the station, the poor equipment during those years, heavy teaching schedules, the shortage (in first years entire lack) of a working force other than the instructors. In more recent years the instructional staff and working forces have been greatly increased, so also has the equipment, and the teaching schedules have been lightened. As it came to be realized that the station was likely to be more than a temporary affair, more ambitious research programs running through several seasons have been planned. Some of these larger researches are still in progress.

In the character of the research undertaken at the station limits are placed by the species of animals and plants available for study, by the environmental conditions, by the available facilities, by the training, experience, and interests of the members of the instructional staff and of the visiting scientists, and to a lesser degree by the training and interests of the advanced students. Up to the present time the majority of the papers have dealt with the systematic survey of the animals and plants of the region. A lesser number are of an ecological character. In the field of zoology after the large group of systematic papers (38), come in order the papers dealing with Arthropoda (20), parasites (17), ecology and animal behavior with 12 papers each. In botany systematic and ecological papers predominate.

A bibliography of papers coming from the station since its founding in 1909 to July 1, 1920, is given at the end of this paper. This bibliography includes, in so far as they could be brought together, the titles of all pieces of research based wholly or in part on collections taken or observations made at the Biological Station. In this manner it is true that a few titles are included which have a small basis on work done at the station. The excuse for including them is that it has seemed to be desirable to have a complete list of all the papers dealing with the biota of the region on which work was done at the station. It has been impossible on other grounds to decide what papers should be included or excluded from the list.

An analysis of the subject matter of the papers listed at the end of this article shows the fields in which research has been done and may point out fields that should receive greater emphasis.

General Character of Paper.	Number.
Zoological	70
Botanical	22
Meteorological	2
Water analysis	1
Biological station (descriptive)	2
Total	97

In the further analysis of the zoological and botanical papers it has been found that some fall within two or more subdivisions of the science, and some deal with more than one group of animals or plants.

ANALYSIS OF ZOOLOGICAL PAPERS.

Type of Paper.	Number of Papers.
Faunistic or systematic	38
Ecological	12
Morphological	4
Embryological	0
Animal behavior	12
Life history	5
Physiological	0
Methods	1
Genetics	1
Parasites (largely systematic)	17

Group of Animals Treated.		
Protozoa		3
Parasitic	3	
Free-living	0	
Coelenterata		1
Porifera		2
Bryozoa		2
Nemathelminthes		8
Free-living nematodes	4	
Parasitic nematodes	2	
Acanthocephala	2	
Platyhelminthes		8
Turbellaria	0	
Cestoda	3	
Trematoda	5	
Oligochaeta		8
Parasitic	2	
Free-living	6	
Mollusca		2
Arthropoda		20
Crustacea	2	
Insecta	17	
Arachnida	0	
Myriapoda	1	
Fishes		6

Amphibia and Reptilia	2
Birds	9
Mammals	2

A study of the above analysis shows that there remain many uncultivated or little cultivated fields relating to the fauna of the region about the station. Some of the more obvious needs are investigations in the following fields:

Further systematic and ecological surveys of all the groups of animals represented in the region, especially the Protozoa, Nemathelminthes, Platyhelminthes, Mollusca, Arthropoda, fishes, and birds. The Porifera present problems relating to the factors of distribution and overwintering. The coelenterate, Hydra, occurs during the early part of the season in enormous numbers. It offers excellent opportunities for physiological work. The factors governing its seasonal occurrence and its distribution in different depths of water are yet unknown.

In addition to the systematic studies on Nemathelminthes and Platyhelminthes there are great opportunities for studies of life histories, physiology, behavior of the free-living stages, the relation of the various parasitic forms to their hosts, effects of the parasites upon the hosts, and modes of control. Intimately associated with some of the Platyhelminth problems are certain problems relating to the molluscs which are hosts to the developmental stages of the trematode worms. The relation of molluscs to fish in Douglas lake are yet untouched. More might be done with the ecology and behavior of species of molluscs.

Although the total of papers relating to the Arthropoda seems to bulk large, the number of species in this group is so large that many papers will be required to do justice to the systematic relations of the group. Nothing has been done with the Arachnida and only one paper with the Myriapoda. Much work could be done on the ecology, life history, behavior, physiology, and embryology of the Arthropods.

The species of vertebrates are better known than the invertebrates, since they are more limited in number and the individuals are larger and more conspicuous. For the fishes further work may be done on the breeding habits, food habits, and embryology. Some similar problems relating to the amphibians and reptiles remain to be solved. There remain many problems relating to the behavior and ecological relationships of the birds and mammals of the region.

It should be borne in mind that the above statements are intended to be suggestive only; they are far from a complete statement of the possibilities in the way of problems offered by the animals of the region.

Analysis of Botanical Papers.

Type of Paper.	Number of Papers.
Systematic	9
Ecological	15
Morphological	1
Embryological	0
Physiological	0
Methods	2

Group of Plants Treated.	
Algae	2
Fungi	1
Liverworts and Mosses	1
Ferns	2
Seed plants	12

From the above analysis it is evident that the lower groups of plants have been inadequately studied. It is further evident that the types of problems demanding much equipment have been practically untouched. These problems must necessarily await the development of an adequate equipment.

In summarizing it may be said that the Biological Station is supplementing the teaching offered by the colleges and universities of the state by offering types of work which cannot be so readily carried on under the conditions imposed by the usual curriculum and by the conditions of life in cities. It presents unusual opportunities and viewpoints. In research accomplished it is making a real contribution to the knowledge of the biota of the state and is attacking certain types of problems not usually undertaken by a biological survey.

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University of Michigan.

SYMPOSIUM ON ZOOLOGICAL TEACHING AND RESEARCH IN MICHIGAN.

II. ZOOLOGY IN THE NORMAL SCHOOLS.

BY BERTRAM G. SMITH.

The primary business of the normal schools is to provide teachers for the public schools, and it is necessary that the majority of these teachers secure their preparation in the shortest possible period of time. Most students entering the normal schools remain for two years only; a much smaller number take three years' work and only a few complete a four years' college course. These conditions govern the entire outlook of zoological teaching in the normal schools and compel the closest scrutiny of educational values in the selection of the subject matter.

Very few prospective teachers look forward to becoming professional zoologists. Most normal graduates will of necessity teach several subjects.

Since every curriculum requires a large number of subjects that are regarded as essential to the general training of the future teacher, there is very little time available for specialization. Zoology is almost entirely an elective subject, and the number of electives permitted each student is very small. The crowded condition of the curriculum is the most serious obstacle in the way of thorough training in this subject. Nevertheless, it is encouraging to note that during recent years the proportion of students taking zoology and other natural sciences has steadily increased.

The academic year is divided into three terms of twelve weeks each. Science classes usually meet two hours per day for four days each week. In a few courses less time is available, and it is necessary to substitute one hour per day for five days each week. In most cases the schedule is subject to occasional interruption from a variety of causes. The brief time available in each course requires that the entire field be divided into a large number of short courses, and the temptation to crowd too much into each of these courses is almost irresistible.

At the Michigan State Normal College students electing zoology may be classified roughly into the following groups: (*a*) those preparing to teach nature study or elementary science; (*b*) those preparing to teach zoology and physiology in the high schools; and (*c*) students in physical education. Since special courses in nature study and physiology are maintained by other teachers, students primarily interested in these subjects need not be segregated in the zoology classes, but are accommodated in those courses that best suit their needs. Students in physical education take one or more courses devoted mainly to anatomy.

Each of the following courses is ordinarily given at least once during the year: Animal Biology 1; Animal Biology 2; Invertebrate Zoology; Vertebrate Zoology; Birds and Mammals; Insect Study; Animal Embryology; Heredity and Evolution; Methods and Technique. A course in Mammalian Anatomy

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has been given occasionally. These courses are so planned as to involve little or no duplication of the subject matter. Only one class is large enough to require division into sections, but certain courses are repeated in the summer session.

Several of these courses involve field work, but the limitations of the schedule make it difficult or impossible to conduct field trips requiring more than two hours. However, the Normal College is so favorably situated that one can get into the field without loss of time, and the situation as regards birds and insects is almost ideal.

In normal schools, biological science must keep close to the people, and stress must be laid on those topics which the student can use in his public-school teaching. But in Michigan the educational possibilities of this field have never been fully developed, and the great need is for teachers competent to make the most of their opportunities. Many students come from schools where zoology has no place in the curriculum, or is so poorly taught as to inspire little enthusiasm or respect for the subject. In the training of such prospective teachers one must start at the beginning, and teach many things that should have been taught in the high schools or even in the grades. There is no lack of interest in the subject, but this interest has seldom been fostered or directed. It is a mistake to think that such elementary work requires only a meager preparation on the part of the normal school teacher. The best preparation is scarcely adequate to deal with the wide range of topics involved, and only out of a profound knowledge of the subject can things be viewed in their proper perspective.

Concerning the opportunities for research in the normal schools one must say that the situation is somewhat difficult. There is so much to be done in the organization and adaptation of the subject matter already available that there is small room for any project to make original contributions to the subject. There is a general opinion that such work is best left to the universities. Yet from the viewpoint of educational theory I am convinced that such an attitude is a mistake. I am reminded of a superintendent of schools who once visited my laboratory. He said that as a student he had been much interested in science, and had once thought of specializing in it, but had finally decided to give it up for education. The would-be research worker who is engaged in normal school teaching is likely to find himself in a somewhat similar situation: he is so busily engaged in promoting science that it is almost impossible for him to do any real scientific work. To be sure, no obstacles are insurmountable for one who is imbued with the true scientific spirit, but it may be asked whether he has any right to attempt research when the pressure of teaching duties is sufficient to tax all his energies. My answer is that the superintendent of schools who leaves his science behind him when he enters the field of educational administration is in no worse plight than the zoologist who abandons research. An occasional voyage of discovery into the twilight zone which marks the boundary between the accepted facts of science and the realm of the unknown is necessary for the preservation of his intellectual outlook. The actual gain for science may be small, but the advantage to the investigator, and indirectly to his students, is immense. The teacher who mulls over and over with successive classes the same subject matter, until it becomes to him as dry as dust, is not likely to inspire en-

thusiasm in his students. And to a certain extent this result is inevitable however much the teacher may revise his courses in the light of new discoveries made by others. Facts obtained second-hand never revive one's interest to the same extent as those obtained direct from nature. The teacher, quite as much as the student, needs this enlivening contact with the unknown. Without it he is likely to forget that many of the accepted principles of biology are founded on a partial knowledge of the facts, that science is ever a changing thing, and theories are discarded like an old coat when it becomes tattered or outgrown. He is not likely to correct the too prevalent impression that everything that is worth knowing has already been discovered, and all that is needed is to apply this knowledge. The realization by the student that scientific discoveries are being made in the laboratory where he studies is one of the best correctives of the ideas that books are the only source of knowledge.

The normal school is no place for the man who becomes absorbed in a long-drawn-out research problem to the neglect of his classes; but there is room for the man who works out an occasional small problem as a recreational activity and a respite from the active duties of teaching. To be sure, whatever is accomplished must be done as "knitting-work," in fragments of time that can be spared from more pressing duties; the character of the problem must be such that it can be taken up or laid aside as occasion permits or demands, but even this intermittent application to research has its rewards.

Michigan State Normal College, Ypsilanti, Mich.

THE OPPORTUNITIES FOR RESEARCH ON THE MICHIGAN BIOTA PROVIDED BY THE MICHIGAN GEOLOGICAL AND BIOLOGICAL SURVEY.

BY ALEXANDER G. RUTHVEN.

The biologists residing in Michigan, or at least those who are interested in ecology and geographical problems, are familiar in a general way with the biological investigations of the Michigan Geological and Biological Survey; but, since there has not been a published summary since 1913, probably few persons not connected with the Survey know what has been accomplished, the amount of work which remains to be done, and the opportunities for investigation in connection with the biological division.

The general object of the survey is conceived to be the securing of data on the animals and plants of Michigan, or, more concisely, a detailed biological survey of the state. It should be clearly understood that the comprehensiveness of this conception makes it certain that the work will never be completed, for it involves every aspect of ecological, systematic, and geographical biology of the Michigan species. It also seems clear that the best progress towards the attainment of a detailed knowledge of the biota of the state cannot be made by attacking a large number of problems not intimately related. But little is known of the variation, geographic distribution, habitat distribution, and life-history of the Michigan species, and this information is not only needed in studies in several fields but also for class use. Until this data has been secured for a considerable part of the state and for many groups, it is believed that such investigations as experimental ecological studies may well be subordinated; and this belief has led to the decision that the first work of the biological division should be:

1. To secure detailed data on the occurrence and distribution of the animals and plants of every part of the state.

2. To secure specific data on the habitat distribution, habits, and life-history of each species.

3. To make available, with the least possible delay, the information obtained, for the use of investigators, economic biologists, and the schools of the state.

It is not the purpose of this paper to present a detailed account of the progress of the biological survey from its inception, but a general summary is essential to a proper presentation of the opportunities for study.

The survey was begun in 1905 and is thus 15 years old. At the time it was inaugurated very little was known of the fauna and flora of Michigan. For example, the Museum of Zoology of the University of Michigan, which is the repository of the Survey collections of animals, had in 1905 practically no collections of Michigan animals except birds, and even many of the species in Washtenaw County used in the university work were wrongly identified. It is true that much had been published on the flora

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and fauna. It is hardly necessary to say that there are many excellent studies by Michigan biologists (some of which appeared before and others since the inception of the survey) in the fields of biology which are now receiving the principal attention of the survey. To name just a few investigations selected at random, the work of Barrows, on birds, Walker, on mollusks, and Beal, Dodge and others, on phanerogams, are important contributions to the biological survey of Michigan. It is not minimizing their value, however, to say that the researches of independent students prior to 1905 are almost insignificant when the amount of data to be obtained is considered, for even when comprehensive in scope they are naturally inaccurate or incomplete, or both. One may say, without undue exaggeration, that when the biological division was found the state presented a practically virgin field for biological studies in the sense that no region or group had been studied in detail.

Two methods of conducting the field work presented themselves, viz., to have it done from one center or to distribute it in such a way that the results would provide, with the least possible delay, general data on the fauna and flora. Of these the last was selected in the belief that it was desirable both from the standpoint of the investigator and the teacher to have a general knowledge of the biota, and that it was advisable to take immediate steps to obtain records of the biota in those regions in which the natural conditions were least disturbed but likely to be changed by the activities of man. This is the principal explanation of the wide distribution of the field work (see the accompanying maps, Plates I-VIII). Upon these maps is indicated the counties in which detailed studies have been made with the support of the Survey, the Museum of Zoology, or both. It is to be understood that only groups that have been studied in some detail are considered; that the entire county has not been covered by the field work in every case; that the field work in almost every place has been limited to a few months; and that the different species in the groups considered have not received equal attention. In other words the maps do not show all of the work which has been done, since the studies of persons not connected with the Survey and minor studies and miscellaneous material of the Survey have not been considered; and at the same time they over-emphasize the investigations of the Survey, because the county has been used as a unit in plotting the areas studied, and the groups have been combined.

It will be seen that large parts of the state have not been studied and that many groups of animals and plants have been practically ignored in the work done for the Survey, and it should be said here that the work of independent students since 1905 has not been sufficient in amount to greatly alter the status of our knowledge of the biota of the state as indicated on the maps. In other words some appreciation may be had from these maps of the amount of work which remains to be done before an adequate knowledge of the composition, distribution and habitat relations of the biota are available.

The relatively small contribution to a complete biological survey of the state which has been made, together with the fact that the investigations have been widely distributed, both geographically and throughout the animal and plant groups, may possibly give the impression, at least to the

casual observer, that the activities of the Survey have been without plan. Such is not the case. As has been said there is a definite plan, and the distribution of the field work is a feature of this plan. It is now to be pointed out that the unequal study of different groups is due to the conditions.

The unequal emphasis placed upon different groups has been and will probably continue to be very largely unavoidable. The state is large, the appropriations for biological studies are limited, the fauna and flora comprise many different orders and a very large number of species, the number of available investigators is small, and the Survey is in its infancy. It is probable that as time goes on it will be possible to study more groups, and it is evident that with larger appropriations more of them could be studied at the present time. But it is equally clear that the situation could be materially improved with the assistance of local naturalists. The Survey is receiving such cooperation now in that many people are sending in desirable specimens and data, and the results of individual investigators, though not obtained with the assistance of the Survey, are being used; but there is need for much more work on the biology of the area.

The need for data on the fauna and flora of the state represents opportunities for research. To emphasize these opportunities it may be pointed out, (1) that for no species is there sufficient information on the life-history, habits, habitat distribution, variation, and geographical distribution in Michigan; (2) that for no group is there detailed information upon the distribution within the state; (3) that for no restricted area within the state is there detailed information on even the composition of the biota; and (4) for many counties practically no data have been secured. It is safe to say that any careful investigation of any species in any region, any detailed studies on the local distribution of the species of any group in any region, and comprehensive studies on any group will provide data which are greatly needed by the biological survey, the schools and the general public.

The biological division stands ready to assist in this work, by getting material identified, by advice as to methods and literature, by assistance in field work and in acquiring needed equipment, and in fact in every way that a teacher assists the research student. Since, then, the Survey can be depended upon, at least for assistance in overcoming the difficulties which usually attend research in places elsewhere than near biological laboratories, the systematic biology, ecology, geography, habits, and life-history of Michigan species are fields of investigation in which results can be obtained by persons with a biological training, no matter where they are situated or what are their facilities. All that is required of the person with proper training is an incentive and aptitude for research and an interest in the fields of zoology which are now receiving the first attention of the Survey.

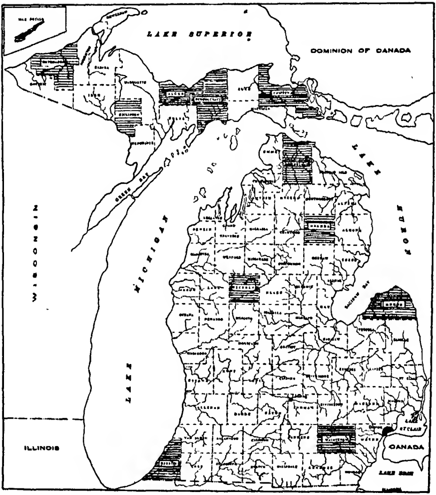
University of Michigan.

EXPLANATION OF PLATES.

Counties in which detailed field studies of Michigan biota have been made:

Plate I—Mammals.
Plate II—Birds.
Plate III—Fishes.
Plate IV—Amphibians and Reptiles.
Plate V—Insects.
Plate VI—Shells.
Plate VII—Cryptogams.
Plate VIII—Phanerogams.

PLATE 1.

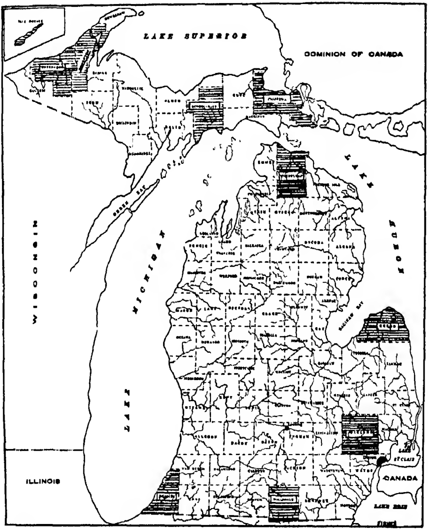


Mammals.

PLATE II.

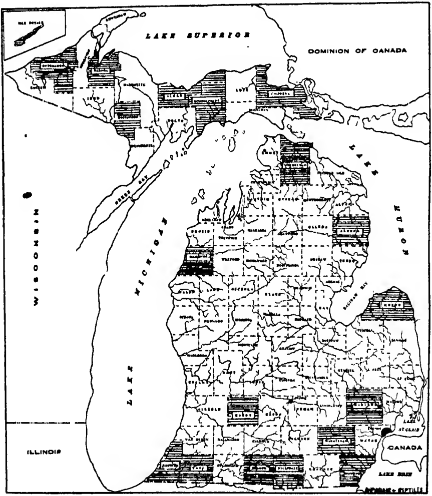
Birds.

PLATE III.



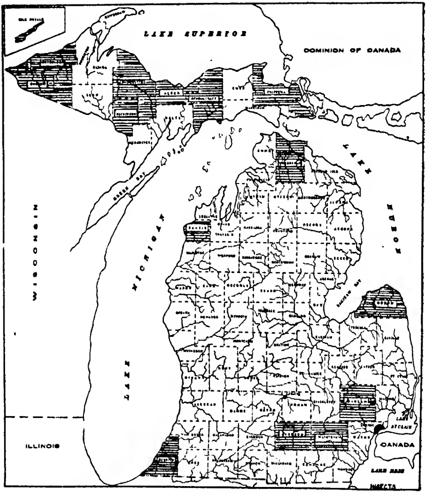
Fishes.

PLATE IV.



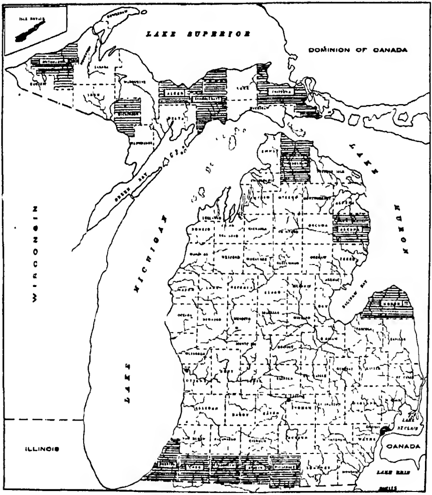
Amphibians and Reptiles.

PLATE V.



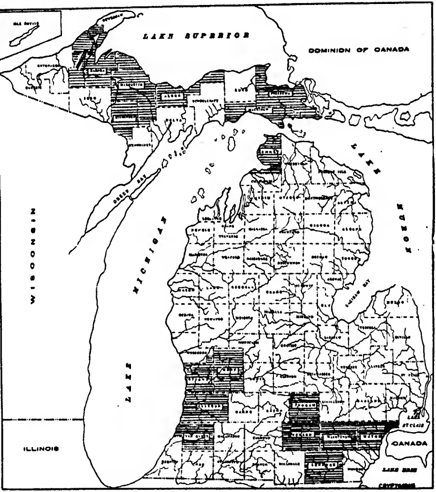
Insects.

PLATE VI.



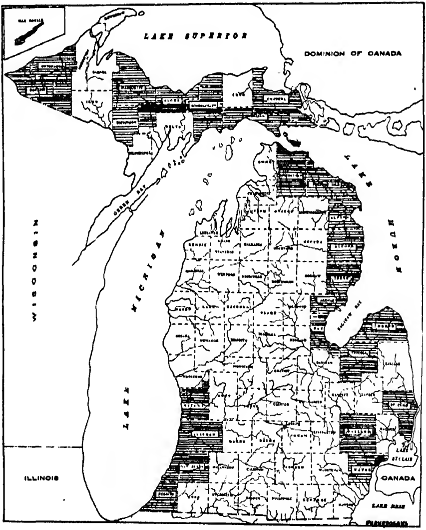
Shells.

PLATE VII.



Cryptogams.

PLATE VIII.



Phanerogams.

RESEARCH IN PRIVATE LIFE.

BY BRYANT WALKER.

I have been asked to speak in behalf of the amateur in science. In college athletics and similar lines of sport, there is a very sharp line drawn between the amateur and the professional; the former doing for love and fame what the latter does for money. This rule in sporting matters is very rigidly enforced and for very obvious reasons. But I do not think that the distinction holds good between amateur and professional scientists It would be very desirable, of course, if every man who desired to devote his life to scientific research, were endowed *ipso facto* with sufficient worldly goods to enable him to pursue his vocation without having to think of material affairs, but that is not the case, unfortunately, and it is the misfortune, and not the fault, of the professional scientist that he is obliged to earn his living in connection with his scientific work. I do not think that there is any lack of enthusiasm in their work among the professional scientists as compared with their amateur brethren. I think that we amateurs fully appreciate the fact that any one who devotes himself to science in these days, does so at a very large personal sacrifice. It means the giving up of all the prospects of worldly success that might come in business or professional life for the sake of following out the natural bent of his own inclinations, and I think we all honor and respect those who have had the nerve to do this, which so many of us have not had in times past.

The amateur in science may be regarded from two different points of view: First, with reference to the effect that his scientific studies have upon himself; and second, the influence that he exerts upon the general cause of scientific endeavor and advancement.

Before such an audience as this, composed of those who are either already professional scientists, or who are endeavoring to become such, and who have been willing to follow their natural inclinations at the expense of their material prosperity, it is not necessary to discuss the joy and pleasure which accompanies all scientific research. There is no greater pleasure in the world than that which comes from a fine piece of scientific work, well done, or the solution of some knotty scientific problem to him who is interested enough to put his best efforts into that kind of work. Much might be said as to the sharpening of the intellectual faculties which come from scientific research; the increase in the power of observation; the training of one's analytic powers and powers of discrimination. Then, too, much could be said in reference to the mere pleasure that the amateur has beyond that which others have, from the fact that in his dealings with the outside world he has something of interest to occupy his attention. And we all know the great amount of pleasure that comes to the friends of the amateur, as he is able to show them the wonders and beauties of nature that lie all around us. But great as is the effect upon the individual, that is not the main point that I desire to make in reference to the amateur naturalist.

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I do not think that many appreciate the great influence that the amateur naturalists and collectors of this and every other country have had upon the general advance in science. I do not think it is an exaggeration to say that were it not for the amateurs the progress of systematic science would be practically stopped and the professional scientist would be without the data upon which he relies as the basis of his expert theories and opinions. I think that it can be truly said that three-fourths of the new species of animals and plants that have been described in this country at least have been discovered by amateur collectors, and the same proposition holds good in regard to a very large proportion of the facts in regard to distribution of the various species in the different states, without which all generalization on that subject would be without an adequate basis. I do not know in detail how it is in other branches of science, but in the one that I am more familiar with the number of professional experts, to whom we are indebted for the greater theories of classification and distribution, can be counted on the fingers of one hand, but the facts upon and from which they work have been very largely furnished by the amateur.

If this is true, it would seem to be clear that it is of great importance to the scientific progress in this country that there would be a large class of such amateur workers who should act as "feeders" to the great museums and to the professional scientists who have them in charge. Just think what it would be for the advancement of the knowledge of the fauna and flora of this state if we had even one amateur collector in each of the 83 counties of the state who should annually turn into the State Survey the result of his individual work in his own neighborhood.

I am very strongly in favor of expeditions, but as every one, who has had experience with them, knows every expedition is more or less of a gamble in regard to the results. The professional naturalist is tied up during the school year with his professional duties. During the summer he takes a month or six weeks, or two months perhaps, at the most, for work in the field. He preferably desires to get into some region that has never been worked before. It is strange to him, as it is to all others, so far as its scientific aspects are concerned, and so he makes a stab in the dark, as it were, as to where he should go. He may hit it and he may not. If he does not, the results of his time and trouble may practically amount to very little. Then, again, such a professional naturalist, and such an expedition in the summer, loses the spring flowers, the spring insects, the spring migration of the birds, and in the same way he loses them all in the fall. The result of such work is therefore necessarily scattered, uncertain, a rainy season or a dry season may ruin any expedition, and so far as a complete knowledge of the district covered is concerned is necessarily imperfect. As contrasted with that, compare the amateur, who is on the ground all the year around, who, in gradually increased circles from his home, works over, season after season, every foot of the surrounding territory, so that in the end he not only knows the whole region covered by his examinations, but he knows everything that is to be found there and where it is to be found, and it is to him that the occasional occurrence of the rare things is more likely to come than to the man who, without exact knowledge of the region, attempts at haphazard to do the same work in a comparatively limited time.

From what has been said, it would seem to be obvious that a large body of amateur assistants in scientific work is very desirable, but what are the facts in regard to such workers? To put it in word, they do not exist. The old-time, all-around naturalist, who had a speaking acquaintance, so to speak, with all the animals and plants of his neighborhood, has gone, and in the place of the naturalist we have the biologist, and instead of the systematic botanist, the morphologist. In my own line of work, outside of Detroit, where there happen to be two, and at Ann Arbor, where there happens to be one, I do not know of a single active collector of the mollusca in this state. Twenty-five or thirty years ago there were eight or ten, and I think the same thing holds true in regard to almost every other branch of systematic work, and yet, it is not on account of the lack of facilities for that work. When I entered college forty years ago or more, the number of high schools in the state, I think, could have been counted on the fingers of both hands, and in them there was not a single teacher of botany or zoology. When I entered the university there was no course in zoology at all, and there was only a rather perfunctory six weeks' course in botany. Now there is a high school not only in every city, but in every village of considerable size in the state, and in every one of those schools there are from one to three professional teachers of zoology and botany, and a more or less elaborately equipped laboratory, and yet, so far as I have been able to ascertain, there has not been a single fact added to our knowledge of our fauna and flora, or its distribution in the state, by any high school teacher in the state, within the last twenty-five years. It seems incredible that such should be the case, and yet, unfortunately, it seems to be absolutely true.

If this is the fact, that in spite of the great increase of population, in spite of the great increase in facilities for scientific work in this state, the number of those who have sufficient interest in scientific matters to make it part of their recreation, if not of their lives, in exploiting scientific work has absolutely decreased, it would seem that there must be something wrong with our system of education. Children are very much the same today that they were twenty-five or thirty years ago. Every boy and every girl, at some time in their lives, developes the collecting instinct, and if that natural tendency could be encouraged and cultivated, there might be found, perhaps, here and there the individual who would develop into a real scientific amateur. At the present time there is no such encouragement, no attempt of anything of that kind, so far as I know, in our public schools.

The theory of education in this state is, that beginning with the lowest grades the student is gradually carried on through the ward school to the high school and from the high school to the university, so that ultimately, in course of years, he may receive from the university his doctorate, the highest degree that the university grants for literary or scientific education. This course, no doubt, has been justified by practical experience, and it may be right in regard to what may be called ordinary or liberal education, although there are evidences, every now and then, of more or less strenuous criticism. But the question is whether a theory of scientific education which starts from the rudiments in the high school and is continued through the university upon the theory that every one of the children in the high school is expected to become a professional scientist is the right one. Of all the children in the high schools of this state, 90% go no further,

and of the 10% that go to the universities less than 10% again devote their attention to scientific studies; so that the practical question is whether the elementary scientific education given in the high schools of the state is such as ought to be given, in view of the fact that nine-tenths of the children never go to college and nine-tenths of those who do never study science. Why should not the high school education in matters of this kind be based upon the theory of the greatest good for the greatest number? What is the possible object in taking hundreds of children from fourteen to sixteen years of age and giving them an elaborate course in microscopic technique, in the study of cells, and all the lower forms of life, when not one out of ten will ever look into a microscope again after leaving school or have any interest in the subject? Would it not be better for those children, for the people of this state represented by those children, and children who come after them, if they could be given some idea in regard to the life that is about them, that they would know something of birds and animals, their habits, migration and their place in the economy of nature, that they might know the common flowers, so that in their vacations in the country they might recognize them and call them by name? Surely such an education as that would be something that would last every child for all its life and would be a continual source of pleasure and possible inspiration for further work along such lines.

I think that the fault in the first place is in the times themselves in a broad way. This is the age of specialization and everything is sacrificed to producing a specialist of some kind, and the fact is that the high school teachers of this state have been so specialized that they are not capable of giving the elementary training, which it seems to me should be given to the children in our public schools. They have not the knowledge to tell their children or to teach them about the common things of nature. They know nothing of things that do not require a microscope to see, and they have no interest in practical, old-fashioned natural history. I do not think that the teachers themselves are so much to blame for this,—they do not know anything different or better. The blame lies farther back and higher up. They have not been taught anything else in the universities, the colleges and normal schools that send them out to instruct the children of this state. They know nothing of general natural history as distinguished from biology, morphology, and all the other technical collateral branches of scientific work, and therein is the great defect in our present system of educating teachers of science, and the fault lies at the doors of the training schools from which they have graduated. It would seem to me that there should be a radical change not only in the common schools, but in the universities, the colleges, and the normal schools which educate the teachers for the common schools along the lines that I have indicated. There is no occasion for having a compound microscope in a public high school at all. It will be time enough to study technical scientific work when the small fraction of the school children who to college, and who desire to study science, shall there undertake to get a scientific education. And until that is done, until there shall be a change in methods, I do not see that there is likely to be any increase in the number of that class of amateur workers who are so desirable and yet have become so scarce.

Detroit, Mich.

THE RELATIONS OF THE ANCYLINE FAUNA OF SOUTH AFRICA AND SOUTH AMERICA.

BY BRYANT WALKER.

(Abstract.)

One of the most interesting results of the modern developments of the study of Zoogeography has been the close relation that have been found between the faunas of Africa and South America. This has been shown to exist in so many different groups of animals and plants that there is at the present time a general concensus of opinion among those who have given the subject special attention that there must have been at some time, or times, a land connection between the two continents. The only substantial difference of opinion has been as to the times when and the places where this ancient land bridge (or bridges) occurred.

In a study of the *Ancylidæ* of South Africa made in 1912 (Walker, Naut., XXV, 1912, pp. 139 to 144), it was discovered that in the largest and most characteristic group of that family found in South Africa the apex was radiately punctate, instead of being either radially striate or smooth as in all other then known groups of the family. This group was named Burnupia.

In 1914 Dr. H. A. Pilsbry (Pr. A. N. S P., 1913, p. 671) defined two new groups of *Ancylidæ* from South America characterized by their having their apices "punctate, pitted or pock-marked," which he named *Hebetancylus* and *Uncancylus*. These groups apparently include all of the so-called *Ancyli* of South America. Within the last year Dr. Pilsbry and myself have detected three new species in Costa Rica, which apparently is the northern range of these groups on the west coast and on the east coast species are known from Venezuela, Trinidad and possibly Cuba.

These South American species in many instances resemble the South African Burnupias in shape and are evidently closely allied in their apical characters.

As none of the Asiatic or mid-Pacific species have similar apical characters, it is clear that they are not derived from any early immigration from the west.

The relationship of these groups is such as to require a common origin, and wherever the parent stock may have originated the existence at the present time of these closely related groups in both continents is another link in the chain of evidence that goes to prove that at some time there must have been land connection between them.

Detroit, Mich.

HYPERSTROPHY IN THE ANCYLIDÆ.

BY BRYANT WALKER.

(Abstract.)

Most species of spiral shells are normally either dextral or sinistral. In dextral species the excretory orifices are on the right side of the animal and in the simistral species on the left side. In all groups of spiral shells reversed examples are found in various degrees of frequency. But in such cases not only the shell but the animal also is reversed.

In some groups, however, dextral shells are found to be inhabited by a sinistral animal and *vice versa* in certain sinistral shells. This is called hyperstrophy.

This condition is supposed to have been brought about by a gradual shortening of the spire until the shell becomes flat or planorboid in shape and by a continuation of this sinking of the spire the shell ultimately assumes a spiral shape but coiled in the opposite direction from the primitive condition. This well illustrated in the family Ampullarriidæ, in which typical *Ampullaria* is a dextral shell, *Ceratodes* is planorboid and *Lanistes* a sinistral shell, but the animal in all remains dextral.

The *Ancylidæ* are a family of small fresh-water pulmonates having a general distribution all over the world. The shell in most of the genera is of a simple, limpet-like shape terminating in a more or less acute apex without any traces of spiral coiling. This apex is not directly on the median line, but is turned more or less excentrically either to the right or to the left.. For this reason they have always been described as dextral or sinistral as the apex was inclined to right or the left. But in all of those genera in which the apex of the shell is inclined towards the right, the animals are sinistral and *vice versa* in those having the apex inclined to the left. For this reason they have almost universally been considered as examples of hyperstrophy.

The only exception that I have been able to find is Pelseener (Mem. Acad. Roy. Belg., LIV, 1901, p. 18), who in treating of the anatomy of *Gundlachia* states that both it and *Ancylus fluviatilis* (both species having the apex turned to the right) are sinistral both in the animal and the shell. But he does not touch upon the apparent contradiction in the position of the apex in these species.

Of the several genera now recognized in the *Ancylidæ* two, *Latia* from New Zealand and *Ancylastrum* from Tasmania still retain the primitive coiled spire, which in *Ancylus s. s.* is lost before the young animal leaves the egg. These apices are very small and are not visible when the shell is viewed dorsally. From above the inclination of the spire in *Ancylastrum* is toward the right, but the spire is actually coiled sinistrally, so that there is complete accordance between the shell and the animal, both being sinistral.

In *Latia* the conditions are exactly reversed. From above the apex is

apparently turned to the left, but as a matter of fact the apex is coiled to the right. The shell is therefore dextral like the animal.

It is clear therefore that neither of these genera are hyperstrophic.

And from analogy it is argued that the same conditions apply to those genera which lose the primitive apex while still in the egg.

It would follow therefore that hyperstrophy does not occur in the *Ancylidæ*.

Detroit, Mich.

STUDIES ON THE ORTHOPTERA OF MICHIGAN IN 1919.

BY T. H. HUBBELL.

Previous to last year, nine papers dealing with the Orthoptera of various parts of the state have been published by Morse, Shull, Hebard, Rehn, Blatchley, Woodward, Vestal, and Pettit and McDaniel, respectively. Besides these, numerous publications contain incidental mention of Michigan forms.

Work in this group was carried on last summer in several parts of the state. Detailed studies were made of the Orthoptera of the Warren Woods Preserve in Berrien county, and of the region along the Wisconsin boundary in southeastern Gogebic county. Reconnaissance work was done in Benzie, Calhoun, Washtenaw, Wayne, Oakland, and Jackson counties during the latter part of the season.

The vicinity of Warren Woods contains a considerable number of Orthopteran habitats, and consequently a rather large and varied fauna. The southern and western elements of the latter are noticeable as compared with that of the region about Ann Arbor. The range of one species, *Melanoplus flavidus* Schudder, was extended east from central Illinois by its discovery at New Buffalo. Another summer's work is planned to cover the dune area, which was very little studied.

The work in Gogebic county was done chiefly in the vicinity of the Hughitt-Rawson preserve on Thousand Island Lake and around Watersmeet. The habitats studied ranged from sedge marshes and tamarack swamps to heavy hemlock-birch and climax maple forest. The Orthopteran fauna is rather restricted, only 32 species being found; as a whole it is boreal, but with a strong western element shown by the occurrence of such forms as *Chloealtis abdominalis* (Thos.) and *Melanoplus bruneri* Scudder. Two forms whose ranges were extended to the northwest are *Acrydium arenosum angustum* (Hanc.), taken at Thousand Island Lake, and *Nemobius palustris* Blatchley, abundant in a sphagnum bog at Cisco Lake.

In all three thousand five hundred specimens of Michigan Orthoptera were added to the collection of the Museum of Zoology during the summer of 1919. Several collections were donated to the university, the largest being an interesting series of 200 specimens from Douglas Lake, Cheybogan county, received from Miss E. P. Butler. In this collection were five species previously unrecorded from the region: *Acrydium arenosum angustum* (Hancock), *Arphia sulphurea* (Fabr.), *Spharagemon collare wyomingianum* (Thomas), *Melanoplus stonei* Rehn, and *Conocephalus viridifrons* Blatchley. *Melanoplus stonei* was taken by the writer at Crystal Lake, Benzie county, in the latter part of August, and the specimens reported by Shull in 1911 from Sand Point, Huron county, as *Melanoplus foedus* Scudder were also recently determined by Mr. J. A. G. Rehn to be *stonei*. Since this species has not been previously known in the United States from west of New Jersey, it well illustrates the need for extensive collecting and detailed field work in this group.

University of Michigan.

DIVISION, NUCLEAR REORGANIZATION AND CONJUGATION IN ARCELLA VULGARIS, EHRENBERG.

H. M. MACCURDY.

II. Conjugation and Fission Rate. (Abstract.)

In a series of pedigreed cultures of *Arcella vulgaris* described in a former paper, it was shown that periods of "depression" occurred at fairly regular intervals. Conjugation was found to occur within these periods more readily than at other times. In fact, conjugation appeared to be almost wholly confined to these periods.

At this time data derived from the records of these pedigreed cultures are given with the fission rate in lines of descent taken at random down through the lines. It was shown that the fission rate for non-conjugants in such lines was more rapid for a period, then less rapid for a period or even entirely suspended for a time. These periods together comprised about a month. In a fewer number of lines the fission rate was less markedly periodical, though the periodicity was always detectable.

The general average for 525 non-conjugant parent cells all from one line for one week was found to be one division for every 2.56 days For a week during the "depression" period, the rate fell to one division for every 4.42 days, and in some cases lower.

When conjugation occurred it was almost without exception within a time of depression for the line. After conjugation the ex-conjugants were isolated and their performance records were kept. The highest average fission rate for any weekly period following conjugation in case of the ex-conjugants was found to be one division for every 1.56 days. In the course of a month the fission rate would fall to a low average and cease altogether in many individuals. Conjugation would again occur in some cultures and these could again be isolated. In the meantime the non-conjugating parallel lines, after the period of delayed fission rate, would again increase to approximately the general average for non-conjugants.

The origin of three daughter cells occurring at "depression" with only chromidial chromatin was observed and these were isolated and their records kept. These all formed "secondary nuclei" from the chromidial net and proceeded to divide as did the individuals of the non-conjugating lines.

Old vegetative nuclei were seen in many cases to be left with some cytoplasm in old shells and to perish. In other cases, as prepared slides showed, these old nuclei were found to be in a state of degeneration.

The evidence points to the conclusion that in *Arcella vulgaris*, nuclear cycles occur and succeed each other, either with or without conjugation; that nuclear reorganization is necessary. The cases tabulated from the records indicate that after conjugation fission is increased for a period, but as there is also an increase in corresponding non-conjugants it is the reorganization of the nuclei, either through conjugation or the formation of secondary nuclei, which may be responsible for the increased rate. Some of the ex-conjugants show a higher rate of fission than the non-conjugants.

Alma College, Alma, Mich.

HISTOLOGICAL VARIATIONS IN RHIZOPHORA MANGLE.

H. H. M. BOWMAN.

The red mangrove, *Rhizophora mangle*, has been for centuries an object of curious interest in the diaries and journals of travelers and explorers and the subject of investigation by numerous botanists, but chiefly on account of this tree's peculiar habit of vivipary and its formation of stilted jungles in salt water on most tropical coasts (Plates Xa, b, and XIIa)

The features of the mangrove considered here are not so much those of its physiological relations or its distribution which have been treated by the writer in other papers (1) but rather some of the peculiarities of its tissues, a matter which has for several reasons not been thoroughly studied before and also to correct several errors with regard to the histology of certain organs as reported in the past These investigations by the writer were carried on for about six years largely at the Tortugas Laboratory of the Carnegie Institution of Washington and other islands in the Gulf of Mexico as well as the Florida peninsula.

The first histological feature which strikes the student of this plant is the great abundance of tannin in all tissues, roots, stems, leaves, fruits, etc. This substance belongs to the group of pyrocatechol tannins which produce protocatechuic acid and phlobaphenes with suitable reagents. The tannin is frequently stored in almost solid dense masses in the cells, or it may be more in solution in the cytoplasm as is found especially in certain cells of the leaves, situated immediately under the epidermis These cells constitute with the water-storage cells of the leaves a true hypodermis.

A rather remarkable fact noted by the writer was the peculiar relation of the size of these tannin cells to the salt content of the water in which the trees grow. While experimenting in the laboratory with transpiration rates and other physiological phenomena it was noted that these tannin-containing cells of the leaves are considerably smaller in plants grown in jars containing high dilutions of sea water with fresh water, and in the field notes it was also observed that off-shore plants growing in pure salt water had larger tannin cells than those of in-shore plants or of trees growing in estuaries of rivers where the water becomes more brackish. A correlation with these facts was the difference in the general thickness of the leaves. Those of plants growing in media of high salt concentration being thicker than those grown in media of higher dilutions. Part of this difference in thickness was duo to the difference in size and the number of rows of water-storage cells just above the palisade tissue, some of the off-shore or high salt concentration plants had an extra or third layer of this water-

(1) a. Bowman, H. H M "Ecology and Physiology of the Red Mangrove," Proc Amer. Philos Soc, vol. VI, No 7, 1917.
b. Bowman, H H. M. Canegie Institution of Washington Year Book, 1915, p. 200.
c. Bowman, H. H. M. Carnegie Institution of Washington Year Book, 1916, p. 188.
d. Bowman, H. H. M. Physiological Studies on Rhizophora," Proc. Nat. Acad. Sci., Dec., 1916.

storage hypodermis. The accompanying figures made from camera lucida drawings show these differences induced in laboratory cultures of plants grown in fresh and salt water. Thus the concentration of the media of growth apparently effects the size and the number of the tannin and water-storage cells of the leaves (Plate IX, Figs. 1 and 2).

In the prop-roots or arching pneumatophore structures which support the main trunk of the tree above the water surface and average tidal levels, the tannin cells are very thickly distributed. These prop-roots are thickly supplied with lenticels and serve not only to lift the trunk above the water, but also to permit of sufficient gas exchange for the plant's metabolism. In addition to these pneumatophore prop-roots sent out from the base of the trunk (Plate Xa, b), the lower branches also send down long, slender, adventitions roots often over a meter in length which are likewise supplied with lenticels and these, too, are closely packed with tannin cells. Both sorts of props help to form the impenetrable jungle of roots and branches so typical of mangrove swamps. The tannin cells are especially thickly scattered in the cortex of these prop-roots, and when suitably stained with ferric or cupric salts appear as in Plate IX, Fig. 2, in cross section or in longitudinal rows of dark-stained cells in the longitudinal sections. Similar sections of the hypocotyls of young seedlings show these tannin cells even more thickly distributed not only in the cortex but in the medulla as well, and they are especially dense in the sub-epidermal regions near the lenticels with which these organs also are well supplied.

Sections of the fruits, too, show dense masses of tannin cells and the stem and bark tissues are crowded with them. The mangrove bark has, of course, been an important commercial source of tannic acid since the middle ages in the tropics and was used by the Arabs (2) from very early times for tanning and in medicine.

Another peculiar histological feature of the roots of the mangrove is the tissue called by Warming (3) "transfusion tissue." This tissue is found in the cortical area of the polp-like roots developed in clusters on the ends of the arched prop-roots and lie deeply buried in the mud. These are the real absorptive organs of the tree and are soft fleshy structures of a light pink color. The cortical cells of these roots are large and round and have very large intercellular spaces so that some are arranged in short strands and others radiate about a more central cell in a group. This central cell is usually elongated and often filled with starch grains while the radiating, round, turgid cells are filled more usually with mucilage which stains slightly with aqueous eosin in fresh material. Warming, who also noted these cells, presumably worked with preserved material and the slight shrinkage produced by the preservatives caused him to observe the wrinkles or lines of tension where the walls touched those of adjacent cells so that when observed through a superimposed cell a peculiar effect is produced which he interpreted as a sort of tube or duct within the cells. He regarded these "verdickungsleisten" as thickenings for support. The writer has been able to show that this is only an optical effect and is not seen if the material is fresh and is mounted in glycerine water. These cells are simply large

(2) Abou'l Abbas en-Nebaty, Introd. to "Ibu el-Beithar" (Leclerq), V. notices des Manuscrits, T. 23.

(3) Warming, E. "Rhizophera Mangle, Tropische Fragmente," Engler's Jahrb fü Syst., Bd. 4, p. 520.

cells filled with mucilaginous sap whose function seems to be the transfer of crude sap from the exterior surface to the vascular strands lying in the center of the root. Illustrations of these cells are shown in a previously mentioned paper by the writer (1a). (Plate IX, Figs 3 and 4.)

The development of the root cap and the origin of the adventitious roots from the lower branches as well as the absorptive roots at the base of the props is of peculiar interest. Van Tieghem (4) has carefully described the process of the formation of the secondary roots. The cells external to the pericycle bulge out with the formation of a little pouch. This adheres to the tip of the new root and forms its cap. The present writer has observed this on trees in the gulf region when specimens are often found with pendant adventitious roots nearly two meters long and on which the little dark cap of dead cells was still adhering. Of course this is soon lost when the root elongates sufficiently to reach the water due to the wave action and the emollient effect of the water on the cells. Several botanists, Schimper, Warming and Johow have imagined that the stimulus for the development of secondary roots is a mechanical injury of some sort or traumatism. The pendant aerial roots as well as the short soft fleshy roots lying in the mud may, according to them, be developed as the result of the bites of crabs, or snails, or other mechanical injury. It is true that several species of crabs do inhabit the mangrove swamps as well as numerous gasteropods, but these the writer has never actually seen injuring the mangrove roots. In the laboratory he has purposely injured or completely removed the tip of a hypocotyl or the main root of a young seedling with the result that fleshy roots whose function is absorption were developed.

Another striking feature in the histology of *Rhizophora* is the almost universal distribution of stone-cells or ideoblasts. These occur in every tissue except those of the flowers, and even here there are some specially lignified elements which will be mentioned later. The stone-cells and ideoblasts are frequently associated with the tannin cells except in the leaves. In these organs the mechanical cells are located among the palisade and spongy mesophyll tissues, while the tannin cells are located between the water-storage cells and the epidermus, as is shown in Plate IX, Fig. 5 These cells are for the most part large elongated acicular structures and may be branched "H" shaped or even stellate. When these ideoblasts are cut it is seen that the cell is almost entirely composed of hard lignified cellulose and that the lumen has been nearly filled up. Leaf sections cut a few micra thick and stained with safranin or other good stain for lignified tissue and then counter stained with methyl green show these ideoblasts brilliantly outlined in red against the green of the mesophyll tissues. The hypocotyls of seedlings and the pneumatophore prop-roots are even more abundantly supplied with these skeletal elements than the leaves. Indeed, so thick and long are they in these organs that if a hypocotyl, for instance, is snapped through with a sharp fracture the long taper-pointed ends of these ideoblasts project above the line of structure like a whitish fuzz quite visible to the naked eye. In the fruit and stem the stone-cells are more compact and almost polygonal in shape corresponding more to that of the stone-cells of other plants and the pits and seeds of fruits. By boiling small pieces of the

(4) Van Tieghem, Ph., et Douliot H., Ann. des Sci. Nat. Botanique, Ser. 7, Tome 7, p. 212.

various tissues in Schultze's maceration fluid, beautiful examples of the different kinds of stone-cells and ideoblasts were secured.

In the flower the writer discovered some special cells in the connective region of the anthers which had never been noted before. The stamens of *Rhizophora* are peculiar, inasmuch as they are of the locular type. The anthers are long and the filaments very short and the pollen sacs are fused and arranged with small round loculi. Over the whole inner face there is a thin exothecial membrane which ruptures at the delicate septa between the loculi, dehiscence of the pollen then taking place with the fall of this membrane. On close study the writer found that the back or connective region of the anther has an area of very peculiar cells, as showns in Plate IX, Figs. 6-9. These cells are rather large and elongated and have minute hoops or spiral ribs running about the sides of the cells and on double staining, these hoops stand out in red showing them to be lignified while the wall of the cell itself is simple cellulose. The purpose of these cells with these singular hoops or bands was a matter of conjecture until the mechanism of dehiscence was watched when it was seen that these cells offer a firm resistance to the tensely stretched exothecium with the approaching maturity of the pollen grains until finally its ruptures along the sides of the rows of loculi and the pollen is shed.

The stem is characterized by having in the stcle of the pericycle a very dense ring of sclerenchymatic tissue. This makes the wood of the twigs and branches exceedingly tough and also difficult to cut on a microtome. The wood of the mangrove is very hard and in Zanzibar, according to Crossland (5), it is used by the Arabs for making houses and furniture, as it is so dense, and also on account of the tannin perhaps or other intracellular products that the termites will not chew up objects made of it. Dr. Brown of the University of the Philippines (6) says that in Manila at the present time mangrove wood is considered the best for household fuel, and also for making the highest grade of charcoal. In the wood markets there it brings the highest price. The xylem elements of the wood contain some prosenchymatic, tracheid-like cells with perforations arranged like transverse slits so that the walls of these structures are ladder-like in appearance. The tannin cells are very abundant in the cortex of the stem and appear as cubical or polygonal cells filled with a fine, granular mass of tannin which takes a very dark color with special reagents for detecting tannic acid. Sphaero-crystals of calcium oxalate occur in some tissues and can be easily seen in sections of the soft, submarine absorptive roots, especially in the pericycle region

The developing fruit and embryo are also filled with tannin cells, and the integument of the seed is filled with it as well as the pericarp of the fruit Very early in the development of the embryo there are two integuments, but the inner of these soon disappeara In a longitudinal section, as is shown in Plate XIIc, this integument appears as a horseshoe-shaped area. Inside this integument is a bit of endosperm which does not function as a storage tissue of reserve food for a dormant embryo as in most other plants, since the mangrove is viviparous and the embryo grows from

(5) Crossland, C "Note on Dispersal of Mangrove Seedlings," Annals of Botany, XVII, p. 267

(6) Brown, Wm H. 'Philippine Mangrove Swamps," Phil. Is Bur. of Agric and Nat. Resources, Bull. No. 17, 1918.

the time of its fertilization without intermission. This tissue is loose and spongy and one author, Haberlandt (7), has attributed a special function to it, viz., it serves somewhat as the chorion does in mammalian embryology. This view is set forth in another paper by the present writer. The cotyledonary end of the embryo is later pushed out of the micropylar end of the embryo sac and of the integument to form a neck or collar-like aril and from this later the embryo hangs after the hypocotyl has pushed out of the fruit. Around this arillar collar an absciss layer of cells is formed and the seedling drops from the parent tree to continue as an independent plant practically without interruption of growth if it immediately finds suitable anchorage.

SUMMARY.

To summarize then these observations it may be stated·

1. That tannin is of almost universal occurrence in the tissues of the mangrove, and especially in those of the prop-roots, stems and hypocotyls of seedlings, and that in the leaves these tannin cells can be experimentally modified in size by variations in the concentration in which the plants grow

2. That the "transfusion" tissue of the absorptive roots does not show the "verdickungsleisten," as reported by Warming, when fresh material is used, but is a loose parenchyma of large cells containing mucilage and separated by very large intercellular spaces.

3. That the secondary roots arise apparently by traumatic stimuli such as mechanical injury to primary roots and laboratory experiments with *Rhizophora* seedlings give credence to the theory of injury stimuli advanced by Shimper, etc.

4. That branched and stellate stone-cells and ideoblasts occur plentifully in nearly all the tissues of the plant.

5. That the locular anthers dehisce, by splitting off of an introrse exothecium occasioned by the strain of an area of unyielding cells, reinforced with lignified hoops, described by the writer, on the external side of the anther.

6. The stem contains a very hard Sclerenchyma ring and the xylem has some tracheid-like elements with ladder-like slits in the walls.

7 Finally that the endosperm is soft and spongy, and that its function is not clearly understood at present, but that it may serve as an intermediary in food transfer between parent and embryo.

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(7) Haberlandt, G "Ueber die Ernahrung der Keimlinge, etc.," Ann. du Jardin Botanique de Buitenzorg, Treub, vol 12, p. 91, 1895

LEGENDS FOR PLATES AND FIGURES

Plate IX, Fig 1 Sections of Rhizophora leaf (a) from salt-water-grown seedlings, (b) from plant grown in brackish solution. Tannin cells rectangular and darkly stained Water storage hypodermis large clear cells above palisade tissue Camera lucida x133.

Fig 2 Section of prop root showing tannin cells in cortex Camera lucida x106.

Fig 3. Longitudinal section of fleshy root. Camera lucida x96

Fig 4 Transverse section of portion of "transfusion tissue" of fleshy root x600.

Fig 5 Longitudinal section of prop root showing "H"-shaped idioblasts and rows of tannin cells Camera lucida x470.

Figs. 6 and 7 Longitudinal and transverse sections of Rhizophora anthers Camera lucida x70 and x340, respectively.

Figs 8 and 9 Longitudinal and transverse section of reinforcing tissue in anthers, strengthened with lignified hoops. Camera lucida x500.

Plate Xa. Mangrove tree with roots dug up to show large spread of prop roots on the ends of the props.

Plate Xb Young mangrove tree growing on flats of oolithic rock at Boca Chica, showing spreading prop roots

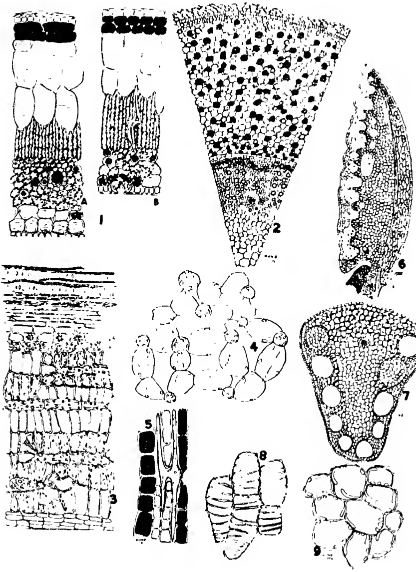
Plate XIa Twig leaves, inflorescence and single flowers of Rhizophora mangle, the Red Mangrove.

Plate XIb Pollinated flowers of the mangrove, developing fruits and fruits with seedlings pushing out the hypocotyls

Plate XIIa. Fruits of the mangrove, viviparous seedlings matured and dropping from parent, also older seedlings with leaves and roots developed

Plate XIIb Microphotograph of section Rhizophora leaf stained for tannin.

Plate XIIc. Section of maturing fruit of Rhizophora showing the embryo inside pericarp with the cotyledonary body, the integuments and some endosperm. Microphotograph x5.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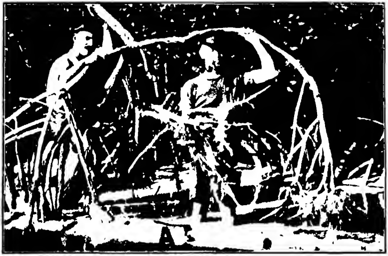

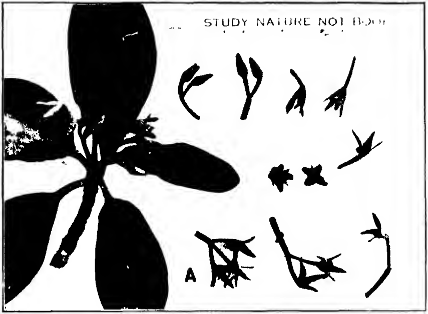
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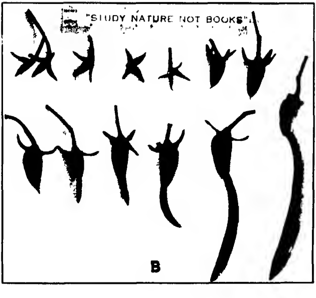
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C

GERMINATION AND GROWTH OF CEANOTHUS AMERICANUS AS AFFECTED BY HEATED SOILS.

BY E. J. PETRY

In performing certain experiments* with *Ceanothus americanus* L., it was necessary to find a method of growing seedlings in as highly sterilized soil as possible. Last year's attempts with soil, here designated as number .1, were unsuccessful because the effect of heating this soil was not known. From data here considered, this soil was finally rejected as unsuited to the greenhouse production of Ceanothus seedlings. Later field studies upon younger plants have shown that ecesis is difficult in the area occupied by this soil, although plants grow fairly well after the age of 5 or 6 years. Since various effects of heated soils upon germination and further growth of seedlings have been obtained by other investigators, it was thought desirable to find out if Ceanothus is affected similarly.

The data here presented will be considered under two heads: "I. Germination" and "II. Further Growth of Seedlings." Since the same seedlings, with few exceptions, are dealt with under both headings, this division is used largely for convenience, as will appear later.

I. GERMINATION.

For germination two hundred sound seeds were used in each test. These tests were made on untreated, on scarified, and on acid-etched (1.84 Sg. H_2SO_4 for ten minutes) seeds, designated by .000, .001, and 002, respectively. Furthermore, these three tests were made on soils heated to three definite pressures in an autoclave with pressure constant for one hour and at the following pressures: (.01) 2 lbs.=103° C. (approximately), (.02) 8 lbs.=113° C., (.03) 16 lbs=122° C., respectively. A pre-heating period of approximately 20, 30, and 40 minutes, respectively, was required. These are conveniently designated 01, .02, and .03, respectively. A similar series was made on blotter paper which had been thoroughly washed in boiling water, and is designated, as the non-sterilized soils are designated, by the symbol .00. The soils used are designated by the symbols .1, .2, and .3, and the source of seeds by 1. and 2., which correspond with seeds collected from large healthy plants in two localities about one mile apart, and from which soils .1 and .2 are taken. Thus, 2.232 indicates seed No. 2, soil No. 2, heated to 16 lbs. (113° C.) pressure, and that the seed was acid-etched.

The soils used were as follows:

.1, a clayey sandy soil from outer ridge of Defiance Moraine (Washtenaw county, Michigan), with very little humus and nitrogen.

.2, a light sandy soil from lower levels of same moraine, also with very little humus and nitrogen.

.3, a compost of sandy loam with muck, manure, and lime used in the greenhouse, and high in nitrogen and total organic matter.

*To be published elsewhere.

The pots and plats were all soaked and washed in large quantities of hot water, and in the cases of the various sterilized soils, were sterilized with the soils contained, in a moist and uncompact condition. In all cases, seeds were planted in from one to five days after sterilization.

The soil was slightly compacted in planting, the seeds being placed at intervals of about 3/4 inches in rows and at a depth of about 3/8 inches. Soil germinations were made in 10 and 12 inch earthenware plats or flats filled to a depth of about two inches with sifted soil (3/16-inch mesh sieve), and these were watered daily by a very gentle spray from a fine nozzle. In this way increased compaction of the soil and injury to the seedlings were avoided.

The following table and its succeeding graphs indicate the rates and amounts of germination under uniform temperature conditions whose daily variations ranged between 60° and 65° F.:

DISCUSSION OF GERMINATION DATA.

Briefly, the data show wide variations in the amount and rate of germination as affected by the four factors designated by the labels. Of these, scarification is the most erratic, and is, accordingly, not graphed except in the germinator tests. With more thorough machine scarification the results of the acid treatment might have been approached more closely and more consistently. Duplication of some of these tests three months later shows a slight decrease in germination, hence, after-ripening is not needed here; however, the seed was stored warm and dry, and might give different results if stored wet and cold, or dry and cold.

Seed 1. has a lower and somewhat more erratic germination than seed 2. This corresponds, in general, with the less favorable locality and soil in which it was produced. On this account seed 2. was used most in the production of seedlings referred to above, and its behavior will, therefore, be discussed at greater length, both here and in the results of transplanting.

All germination tests in soils show retardation, and depression of total germination except that heat .01 in soils .1 and .2 and heat .03 in soil .3 show an acceleration at the beginning, but this is not sustained, causing the total to fall below that of the germinator (blotter) tests.

In soils .01 (compare graphs 27, 28, 29, 40 to 47 in Plate XIV) the rate increases from the untreated condition to the second heat; then it falls rapidly as the temperature of sterilization rises. This is graphically shown by the angles below graph 47, where the slanting line has the same angle (with a perpendicular line) as the graph showing the highest rate for the given heat, respectively. This angle is obtained by taking the base of the three-day abscissa as the vertex and a point in the germination graph, at which germination has almost reached maximum, as the directrix. It is therefore only an approximation which aids the eye in comparing the various rates when the lower sides of the angles so produced are brought together as below graphs 47, 48, and 49. The total germination increases from .20 to .21, then falls rapidly at .22, but less rapidly toward the third heat. See graph 47.

In soil .2 (compare graphs 4, 5, 7, 12, 14 to 19, 21 to 26 [Plate XIII], and 48) there is a higher rate of acceleration up to the first heat, then a rapid decline which, however, does not reach such a low point at heat .03 as

Table 1.

GERMINATION OF CEANOTHUS AMERICANUS L. IN DIFFERENT SOILS HEATED TO DIFFERENT TEMPERATURES.

Soils 1, 2, and 3. Heats .00 = none, .01 = 2 lbs., .02 = 8 lbs., .03 = 16 lbs. pressure. Seed treatment: .000 = none, .001 = scarified, .002 = H_2SO_4 pure, 10 minutes. 1.00 and 2.00 = seeds on filter paper. 200 seeds in each test.

Date Planted, 1919	Label: Seed, soil & treatment of each	No. of Graph	Dates of Counting Sprouted Seeds.						Total germination %
			11-27	12-3	12-6	12-13	12-19		
11-21-19	1.110	----------	0	0	0	0	0	----------	0
"	2.110	44	13	19	20	20	20	----------	10
"	1.111	----------	7	9	10	10	10	----------	5
"	2.111	----------	8	18	20	22	22	----------	11
"	1.112	43	9	19	27	29	30	----------	15
"	2.112	40	20	86	97	108	110	----------	55
"	1.210	17	37	40	42	42	42	----------	21
"	2.210	22	73	80	80	80	80	----------	40
"	1.211	----------	41	45	48	48	48	----------	24
"	2.211	----------	59	86	100	106	106	----------	53
"	1.212	15	51	57	59	60	60	----------	30
"	2.212	21	60	93	111	119	120	----------	60
"	1.310	----------	0	0	0	0	0	----------	0
"	2.310	39	8	15	18	18	18	----------	9
"	1.311	----------	5	6	11	12	12	----------	6
"	2.311	----------	6	7	11	12	12	----------	6
"	1.312	32	8	13	19	24	24	----------	12
"	2.312	37	9	17	29	30	30	----------	15
"	1.120	45	1	8	11	12	12	----------	6
"	2.120	46	0	6	9	12	12	----------	6
"	1.121	----------	2	9	12	12	12	----------	6
"	2.121	----------	4	11	12	12	12	----------	6
"	1.122	42	15	27	35	48	48	----------	24
"	2.122	41	19	38	59	78	78	----------	39
"	1.220	19	0	5	6	6	6	----------	3
"	2.220	26	1	5	6	6	6	----------	3
"	1.221	----------	1	5	11	12	12	----------	6
"	2.221	----------	3	16	26	30	30	----------	15
"	1.222	16	12	21	48	60	60	----------	30
"	2.222	23	19	31	35	73	73	----------	36.5
11-21	----------	----------	11-26	11-29	12-3	12-6	12-15	12-25	Total %
"	1.320	----------	0	0	0	0	0	0	0
"	2.320	38	0	0	5	24	24	24	12
"	1.321	----------	0	0	0	0	0	0	0
"	2.321	----------	0	7	12	35	42	42	21
"	1.322	33	0	2	5	12	12	12	6
"	2.322	35	0	6	28	35	67	67	33.5
			11-26	11-29	12-3	12-6	12-15	12-25	Total %
11-20	1.330	31	0	15	25	27	27	27	13.5
"	1.331	----------	0	17	26	35	36	36	18
"	1.332	30	0	31	41	42	42	42	21
"	2.330	36	1	30	41	42	42	42	21
"	2.331	----------	3	38	55	61	61	61	30.5
"	2.332	34	16	71	88	90	90	90	45
11-21	1.230	20	0	0	0	5	6	6	3
"	2.230	25	0	10	17	29	36	36	18
"	1.231	----------	0	5	7	7	7	7	3.5
"	2.231	----------	0	15	22	31	37	37	18.5
"	1.232	18	0	7	18	30	34	34	17
"	2.232	24	7	19	23	44	59	60	30
12-10	----------		12-15	12-20	12-25	12-30	1-2-20	1-9-20	Total %
"	1.130	----------	0	0	0	0	0	0	0
"	2.130	28	0	1	2	6	11	14	7
"	1.131	----------	0	0	0	3	5	6	3
"	2.131	----------	0	2	7	15	21	22	11
"	1.132	29	0	0	2	3	5	8	4
"	2.132	27	0	3	8	21	24	26	13
12-3	----------		12-7	12-11	12-16	12-20	12-26		Total %
"	1.000	3	8	21	39	47	48	----------	24
"	2.000	10	14	37	59	64	64	----------	32
"	1.001	2	11	29	60	71	74	----------	37
"	2.001	9	19	46	99	122	126	----------	63
"	1.002	1	10	29	89	92	92	----------	46
"	2.002	8	21	42	98	130	145	----------	72.5
11-3-19	----------		11-14	11-21	11-27	12-4	12-14		Total %
"	1.200	7	3	9	14	19	22	----------	11
"	2.200	14	5	12	17	28	35	----------	17.5
"	1.300	6	4	10	17	21	24	----------	12
"	2.300	13	10	25	31	36	37	----------	18.5
"	1.201	----------	5	10	12	16	26	----------	13
"	2.201	----------	15	35	41	52	60	----------	30
"	1.202	5	10	19	23	32	32	----------	16
"	2.202	12	23	48	57	58	60	----------	30
"	1.301	----------	18	17	15*	16*	18*	----------	9 *
"	2.301	----------	9	15	24	35	42	----------	21
"	1.302	4	17	29	37	42	44	----------	22
"	2.302	11	10	30	40	61	74	----------	37

* Insect work, error probably 1%.

in soil .1. Since the total germination is very high at heat .01 and relatively high at heat .03 this difference together with the better effect on the later growth of seedlings, noted later, makes this soil much better adapted to the growth of these seedlings in quantity.

In soil .3 the results are practically a reversal of those found for soils .1 and .2, inasmuch as heat .01 exerts a most deleterious effect on germination. However, if seedlings are not immediately transplanted from heat .03 plats, their roots are soon killed back to varying distances from their tips. Heat .02 is therefore the safest while at the same time it gives a good total germination. This may be understood from graphs 4, 5, 6, 11, and 13, and graphs 30 to 39 with graph 49 in the plates.

Graphs 47, 48, and 49, together with their respective subjoined indices of germination rate, however, do not indicate all of the important differences. Seedlings in soil .3 are not as nearly normal in this soil when it is heated to the second or third heat, as they are under corresponding conditions in soil .2.

The seedlings of soils .10, .20, and .30 are much alike, while those of .13 and .23 are less similar and those of .33 are much smaller, indicating a reduced metabolism in the latter, due perhaps to a toxin. Seedlings of seed 2. are more uniform and larger in all cases than those of seed 1.

Throughout these experiments there seems to run a rough correlation between rate of germination and total germination.

In the absence of exhaustive chemical data showing what chemical changes have taken place in heating these soils to these temperatures, it is impossible to explain these data or to theorize profitably.

The physical character of these soils is only slightly changed by heating and can hardly account for these vital differences, inasmuch as the change noted, namely, a tendency to compact more easily, was somewhat uniform in all cases.

Practical Conclusions. As will be noted later, the highest sterilization of soil .3 is toxic to the further growth of roots. This soil, considering its toxicity at heat .01, can therefore be profitably used for germination only when transplanting is done, especially if the seedlings are to have the advantage of starting in a sterile soil.

If rapid and high total germination are desired, soils .1 and .2 can be employed at the lowest heat here used. When it is not feasible to transplant, soil .2 at heat .02 has given the best results in vigor and normality in Ceanothus, compatible with highest sterilization of the soil.

Reheating soil .1 at any of the pressures does not improve it for germination, as shown by numerous experiments last year. No reheating experiments were tried with soils .2 and .3. Four months after heating, the toxicity of these heated soils had not entirely disappeared with respect to germination, although the plants grew very well. From this it would seem that at least two kinds of toxicity are here concerned.

II. FURTHER GROWTH OF SEEDLINGS.

In the following experiments seedlings were transplanted from the various soils used in germination to similar, and to other combinations of soil and soil treatment, one series of which is shown in Table 2, where the full label covering all soil and seed conditions is written as a fraction. This

fraction shows the germination conditions in the numerator, while the conditions of soil, etc., to which the plants are transferred are shown in the denominator.

It might have been assumed that, if seedlings have the same size, the influence of seed treatment and soil conditions during germination would be negligible. The data indicate no differences attributable to seed treatment, but that the soil can have an effect at this stage is shown clearly in Table 2.

Three plants each were further grown in 5-inch pots, and in many cases three plants represented two types of seed treatment and the untreated seed. The great uniformity of plants, which were labeled, makes it impossible to attribute any influence to seed treatment.

It has been planned to try all combinations of seed and soil and their treatments, but time and facilities finally limited the transplantations mainly to seed 2., although seed 1. was used to some extent. Soil .1 whose action on further growth of seedlings was already known for the highest sterilization, was used only at lower sterilizations.

Seedlings of seed 2. were transplanted from and to soils .2 and .3 with the various heat treatments. The combinations in Table 2 were observed daily for various reactions, particular attention being given in the first three weeks to the detection of any handicap due to transplanting.

From the third to the eighth week after transplanting, careful attention was given to rate of growth, color of leaves and stems, chemical injury and the causes of death. Insects gave little trouble, though the white fly and sow bug vitiated a few tests.

Checks on retardation due to transplanting were retained in the form of a few seedlings left in the germination plats for several weeks. Thus by carefully bringing the soil to the proper humidity and using a specially constructed transplanting forceps it was made uniformly possible to transplant so that no handicap, due to this operation, could be detected within the following three weeks.

The primary roots at the time of transplanting varied considerably, being from 1 to 3 inches in length while the secondary roots were either very short or were absent in most cases. Transplanting took place at from two to four weeks after germination, and care was taken to have seedlings in the same pot and series uniform as to size and other characters

Copious notes were taken, inasmuch as it was found impracticable to photograph the numerous series in sufficient size to show differences which were continually changing. A brief summary of these daily notes will therefore express the larger differences which are partly indicated in Table 2.

DISCUSSION OF FURTHER GROWTH OF SEEDLINGS.

At the center of each quadrangle in Table 2 lies a group of four transplantings which gave the best growth compatible with highest sterilization. As might be anticipated, these are the combinations used most in the larger problem mentioned at the beginning of this paper. These plants after ten weeks' growth, are in nearly all respects superior to those in the right-hand marginal column of each quadrangle, respectively, except that they seem slightly more susceptible to fungous attack in the root system, but this amounts to an advantage in the larger purpose for which they were grown. In general, any variation within these inclosed rectangles is parallel with,

Table 2.

Reciprocal combinations of seedlings sprouted under soils and soil conditions with these soils and treatments in pots to which seedlings were transplanted. Central rectangle (four combinations) in each quadrangle represent the ones most used, while the border combinations are represented by from two to five pots only.

2.33 / .33 Toxic + Change rapid	2.33 / .32 Better	2.33 / .31 growth	2.33 / .30 Very good	2.33 / .23 Toxic Change slow	2.33 / .22 Better	2.33 / .21 growth	2.33 / .20 Good
2.32 / .33 Poor growth	2.32 / .32 Slight Good	2.32 / .31 differ-ences	2.32 / .30 Good	2.32 / .23 Poor growth	2.32 / .22 Slight Good	2.32 / .21 differ-ences	2.32 / .20 Fair
2.31 / .33 Poorer growth	2.31 / .32 Good As	2.31 / .31 above	2.31 / .30 Good	2.31 / .23 Poorer growth	2.31 / .22 Good As	2.31 / .21 above	2.31 / .20 Fair
2.30 / .33 No growth	2.30 / .32 Poor	2.30 / .31 Fair	2.30 / .30 Good growth	2.30 / .23 No growth	2.30 / .22 Poor	2.30 / .21 Fair	2.30 / .20 Good
2.23 / .23 Toxic Change slow	2.23 / .22 Better	2.23 / .21 growth	2.23 / .20 Good	2.23 / .33 Toxic + Change slower	2.23 / .32 Better	2.23 / .31 growth	2.23 / .30 Good
2.22 / .23 Poor growth	2.22 / .22 Better Slight	2.22 / .21 growth differ-ences	2.22 / .20 Good	2.22 / .33 Poor growth	2.22 / .32 Better Slight	2.22 / .31 growth differ-ences	2.22 / .30 Good
2.21 / .23 Poorer growth	2.21 / .22 As	2.21 / .21 above	2.21 / .20 Good	2.21 / .33 Poorer growth	2.21 / .32 As	2.21 / .31 above	2.21 / .30 Fair
2.20 / .23 No growth	2.20 / .22 Poorer	2.20 / .21 Poor	2.20 / .20 Fair	2.20 / .33. No growth	2.20 / .32 Better	2.20 / .31 growth	2.20 / .30 Fair to good

though not as intense as, that of any adjacent margin where in all cases growth is better from left to right. But in the vertical margin the results are somewhat surprising in that the growth is progressively poorer in descending the left-hand marginal column, whereas in the right-hand column

all plants grew well even if those at the top did noticeably better than those at the bottom.

These marginal results, as well as the central rectangles, are not comparable in the different quadrangles because the fertility of the soil soon comes to be a controlling factor; therefore only qualitative characters, such as color, pubescence, and chemical injury can be easily contrasted But rectangles lying on the diagonals of the table are, in general, fairly similar.

If toxicity in soils is caused by heating, then the results of these marginal tests leads irresistibly to the conclusion that the seedlings are to a notable extent immunized to the further inhibitory action of this or some other poison or inhibiting agent, and that this occurs during germination and a subsequent short period of growth.

This is further emphasized by comparisons between quadrangles where seedlings from soil .3 grew better in soil .2 than seedlings germinated and grown in soil .2. When it is recalled that heated soil 3 is more toxic than soil 2, as indicated by the germination data, this conclusion receives added support.

A close inspection of the plants represented by all right-hand margins of the quadrangles in Table 2 brings out the question of whether unsterilized soils are not also somewhat toxic Early in this work it became evident that germinator seedlings rarely succeeded in sterilized soils even if most carefully planted. Later tests showed much less growth of these seedlings in such soils if unsterilized than seedlings obtained from these soils showed; but this was then ascribed to greater injury of the germinator seedlings in planting due to the fact that their roots were more fragile Now, however, it seems more reasonable to attribute this effect almost solely to an immunity conferred by the unsterilized soil. This conclusion is made more certain by the later data derived from many transplantings wherein, with proper controls, it was found impossible to detect any handicap.

Thus the practical conclusion is reached that transplanting to a soil of higher sterilization than that of the seed bed is hazardous for *Ceanothus americanus*, whereas the reverse order of procedure is not only safe but produces a better growth continuously.

Thus far, little has been said of the relative growth of transplanted seedlings during the first three weeks.

In the left-hand column of each quadrangle in Table 2 a sudden check to growth was noted in all cases. Plants at the foot of these columns soon died. The others slowly recovered and the top ones grew well after about two weeks. It will be remembered that most of these at the top had sustained root injury in germination and while they ultimately made a large growth, they early began to develop abnormalities, such as curling of leaves and death of leaf tips. However, in from eight to twelve weeks most of these plants began to grow more nearly normally.

It seems that toxicity must have been rapidly lost in this soil. A similar change seems to take place more slowly in soil .2. Moreover, soil .2 seedlings did not grow as well in the homologous position of the soil .3 quadrangle as in that of the soil .2 quadrangle. This seems to indicate that soil .2 is not so toxic as soil .3; especially is this true if immunization corresponds to the degree and kind of toxicity present in the seed bed. Resumption of normal growth in soil .23 is, however, relatively less rapid,

hence it is to be inferred that while soil .23 is less toxic than .33, it at the same time does not lose toxicity so rapidly.

These results recall some of the data obtained by Johnson,* especially with tomatoes. Doubtless soil .33 would lose its toxicity if kept warmer than in these tests; doubtless, also, it would develop less toxicity at the beginning if it were heated more highly or for a longer period. No reheating experiments were performed with this soil.

The temperature (65° F.) at which these plants were grown is probably a minimum for the species of Ceanothus, but was intentionally maintained at this point in order to depress metabolism during periods of little sunshine.

If performed during the summer months a larger growth in general might be expected, together with a more rapid change in toxicity in all those tests involving the heated soils, but the other correlations would very likely be maintained.

The seedlings of the central rectangles and those on the right-hand margins compare very favorably in size and vigor with one-year-old wild seedlings grown in comparable soils.

CONCLUSIONS.

1. Seeds of *Ceanothus americanus* L. produced in different areas, germinated at different rates in heated soils.

2. The general effect of a heated soil, such as retardation of germination of these seeds, is qualitatively the same in all cases.

3. The higher the amount of organic matter contained in a soil the stronger is the lowering effect on total germination.

4. A very fertile soil was found to be less inhibitory at higher sterilization than at the lowest heat here used. A still less toxic condition of this soil for Ceanothus might be looked for at still higher temperatures of sterilization.

5. Upon standing for three or four months these soils lost much of their power to inhibit germination. Whether this was due to micro-organisms or not is not known for these soils.

6. Seedlings at the age of two to three weeks can be transplanted without checking growth if the soil moisture is brought to a slightly higher amount than the optimum for growth. This condition exists when the soil is not too wet to aerate freely.

7. Saturated or semi-saturated soils results in early death of seedlings

8. Sulphuric acid 1.84 sg. if allowed to act for exactly 10 minutes greatly increases germination, and if the seed is thoroughly washed (nine times) with distilled water there is no injurious effect

9. Hand scarification gives too erratic results to be of value in accurate germination tests.

10. There is no after-ripening effect if this seed is stored warm and dry.

11. In the most toxic of the three soils tried, germination is at first more rapid than in the germinator where maximum germination conditions are supposed to exist, hence a true acceleration may here be recognized.

*Soil Science 7, Jan., 1919.

12. A medium sandy soil with little organic matter was found to be best for germination and further growth of seedlings when these are desired in a medium of maximum sterility.

13. A rough correlation exists between rate of germination and total germination.

14. Very fertile soils, if highly heated, should not be used for germination unless the seedlings are to be transplanted when quite young. Injury to the roots invariably resulted in these tests.

FURTHER GROWTH OF SEEDLINGS.

15. Seedlings grown continuously in sterile soil are more susceptible to root diseases.

16. Seedlings from a sterile soil transplanted to a less sterile soil generally thrive while in the reverse case the wider the differences of sterilization the greater is the injury to the seedling and at the extremes of these tests very few seedlings survived.

17. Some kind of immunity or acclimatization is produced by a sterile soil which permits the seedling to grow better in this soil than it would if germinated in untreated soil or without soil.

18. This immunity increases as toxicity increases and is produced during and immediately following germination. No satisfactory explanation of this effect has yet been formulated.

19. Original fertility of the soil must be considered in estimating the effects on the further growth of seedlings in heated soils.

20. Unheated soils seem somewhat toxic, but the relative toxicity of the soils here used was not determined. Some allowance for concentration of the soil solution must doubtless be made for a brief period after transplanting.

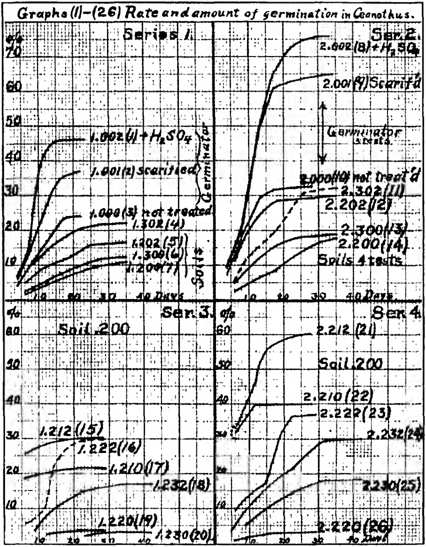
21. Toxicity to further growth of seedlings was lost at different rates in the different soils. The more fertile and more toxic ones lost toxicity more rapidly at the temperature (65° F.) employed.

University of Michigan, April 1, 1920.

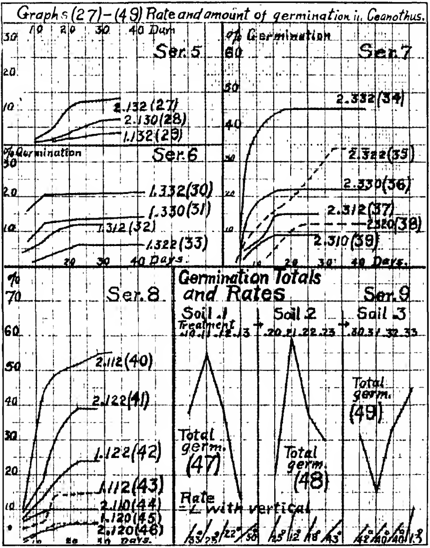
EXPLANATION OF PLATES.

Plate XIII—Graphs 1 to 26, showing rate and amount of germination of **Ceanothus.**

Plate XIV—Graphs 27 to 49, showing rate and amount of germination of **Ceanothus.**



Graphs (1)–(26) Rate and amount of germination in Ceanothus.
Series 1.
1.002 (1) + H_2SO_4
1.001 (2) scarified
1.000 (3) not treated
Germinator
1.302 (4)
1.202 (5)
1.300 (6)
1.200 (7)
Soils
40 Days
Ser. 2.
2.002 (8) + H_2SO_4
2.001 (9) Scarif'd
Germinator tests
2.000 (10) not treat'd
2.302 (11)
2.202 (12)
2.300 (13)
2.200 (14)
Soils 4 tests
10 20 30 40 Days
Ser. 3.
Soil .200
1.212 (15)
1.222 (16)
1.210 (17)
1.232 (18)
1.220 (19)
1.230 (20)
Ser. 4
Soil .200
2.212 (21)
2.210 (22)
2.222 (23)
2.232 (24)
2.230 (25)
2.220 (26)


Graphs (27)-(49) Rate and amount of germination in Ceanothus.
Ser. 5
2.132 (27)
2.130 (28)
1.132 (29)
Ser. 6
% Germination
1.332 (30)
1.330 (31)
1.312 (32)
1.322 (33)
40 Days.
Ser. 7
% Germination
2.332 (34)
2.322 (35)
2.330 (36)
2.312 (37)
2.320 (38)
2.310 (39)
40 Days.
Ser. 8
2.112 (40)
2.122 (41)
1.122 (42)
1.112 (43)
2.110 (44)
1.120 (45)
2.120 (46)
Days.
Germination Totals and Rates
Ser. 9
Soil .1
Treatment
Soil 2
Soil .3
Total germ. (47)
Total germ. (48)
Total germ. (49)
Rate = ∠ with vertical

RESPONSE OF SENSITIVE STIGMAS TO UNUSUAL STIMULI.

F. C. NEWCOMBE.

For over fifty years sensitive stigmas have been objects of study (1). The movements of the stigma lobes may be considered as related to the germination of pollen or to cross-fertilization, the pressure stimulus causing the movement being given normally by the visiting insect. The species having stigmas sensitive to pressure are found in the families Bignoniaceae, Martyniaceae and Scrophulariaceae, and in the genera Catalpa, Tecoma, Martynia, Mimulus, Diplicus and Torenia.

The external and internal morphology of the stigmas in all these genera is very similar. The pistil has two flat stigma lobes hinged at the top of the style, these lobes diverging widely until stimulated by pressure when they close together, requiring, when in good condition, but 2 to 3 seconds to move through an angle of 90° or more. The inner surfaces of these lobes are covered with papillate cells, and the papillate cells are underlaid with a stratum of branching cells with large lacunae between them. It is assumed that the movement of the stigma lobes is accomplished, as with the leaves of Mimosa, by the extrusion of water from turgid cells into the intercellular spaces.

The behavior of these sensitive stigmas is divisible into two reactions: First, the pressure or bending of the stigma lobes causes the closure of the two lobes together; and second, the presence of pollen causes the lobes to remain closed permanently. If no pollen is present on the stigmatic surfaces when the lobes close together, they open again in 10 to 30 minutes. I have found that wheat flour may be substituted for pollen to keep the stigma closed in *Tecoma radicans* (L) Juss. and *Catalpa speciosa* Warder, but the flour will not keep the stigma of *Mimulus glabratus* HBK., var. Jamesii (T. & G.) Gray closed. Fine emery flour will not keep closed any of the stigmas of the three species just named, though Brown states that quartz kept the stigma of Martynia closed.

Carefully submerging the pistil with open stigma lobes in water will not cause closing, but a droplet of water inserted in the angle between the lobes when the stigma is in the act of closing will cause the lobes quickly to reverse their movement.

Immersing the pistil in alcohol or hot water causes very prompt closing; but in strong vapor of ammonia the stigma lobes do not begin to close for 10 to 15 minutes, and continue slowly to close for an hour.

(1) Hildebrand Bot. Zeit. 1867.284. A review of work published by Delpino in Florence, to which the reviewer adds such observations of his own. Batalin. Bot Zeit 1870.53. Darwin, C. Effects of Cross and Self-fertilization in the Vegetable Kingdom 1883, Chap III. Oliver. Ueber Fortleitung des Reizes bei Reizbaren Narben. Ber. Deutsch Bot. Gesellsch. 5.162. 1887. Lloyd Certain Phases of the Behavior of the Stigma Lips of Diplicus glutinosus Nutt. Plant Word, 14 257. 1911. Brown. The Phenomena of Fatigue in the Stigma of Martynia. Philippine Journ. Sci. C Bot., 8:197. 1913. Burck. On the Irritable Stigmas of Torenia Fournieri and Mimulus luteus, and on the Means to Prevent the Germination of Foreign Pollen on the Stigma. Proc. of the Section of Sciences Konin. Akad Wetensch. Amsterdam, 4:184. 1902.

A weak, induced electric current, sent from the tip of a stigma lobe to the style, causes very prompt closing, the stigma subsequently opening.

With a sharp razor the style may be cut through within two millimeters of the insertion of the lobes without stimulating any movement, but if the style is crushed with the forceps even 10mm. from the lobes, they will fully close in Catapla and partly close in *Mimulus glabratus* var. *Jamesii*. Squeezing the style between fingers and thumb will cause closing of the lobes in Catalpa and partial closing in *Mimulus glabratus* var. *Jamesii*.

The behavior of the stigma lobes toward cool water, toward hot water, alcohol and electric current, and toward crushing of the style harmonizes with the hypothesis that the ordinary closing of the lobes is due to extrusion of water from a turgid tissue. The phenomena are illustrations of the well-known fact that many unusual factors may start in motion a mechanism in living beings that has been specially attuned to other factors or stimuli.

The nature of the second response of the stigma lobes, namely, the continuation of the closure when pollen, or flour, or quartz flour has been placed on the stigmatic surfaces remains unexplained.

University of Michigan.

CONTRIBUTIONS TO THE FLORA OF GOGEBIC COUNTY, MICHIGAN.[1]

H. T. DARLINGTON.

Part I.

In cooperation with the Michigan Geological and Biological Survey a study of the flora of Gogebic county was planned, the work to begin in the summer of 1919. This county was chosen because of the desirability of examining those portions of the state which are known to contain large areas of undisturbed or virgin timber.

The present paper deals with the flowering plants and ferns seen during a period of about four weeks during the latter part of the summer of 1919. During the early summer of 1920 nearly the same ground, as well as some additional areas, was examined for the earlier flora The additional species found will be included in another paper. A third paper by Dr. E. A. Bessey will list all the fungi.

Acknowledgments are made to Mrs. Agnes Chase, Department of Systematic Agrostology, U. S. Department of Agriculture for the identification of species of Muhlenbergia, and to Dr. Karl Wiegand of Cornell University for the examination of the genus Amelanchier.

Gogebic is the most westerly county of the Upper Peninsula. On the south and west it touches the northern boundary of Wisconsin. On the northwest there is a considerable shore line on Lake Superior. Briefly, Gogebic and Ontonagon counties together form a broad triangular wedge between Wisconsin and a portion of the Lake Superior shore. Physiographically, the two counties have many features in common. Most of this entire area drains northward into Lake Superior, the largest streams of this slope being the Ontonagon river, the Presque Isle river and the Black river. However, a portion of southeastern Gogebic county, near Watersmeet, drains eastward through the Menominee river into Lake Michigan. A large proportion of this watershed consists of undulating ground, broken by hills often rising to a height of from 500 to 1,500 feet above the level of Lake Superior. In Gogebic county these hills, or mineral-bearing ranges, are most marked in the region extending from Gogebic Lake west to the Montreal River, which forms the western boundary of the county. This area includes the great ore-producing centers of Bessemer and Ironwood. The more or less open character of this part of the county, with its numerous rocky outcrops in places, is different in appearance from the southeastern part. In this latter section, the surface has been covered with a sandy, gravelly, morainic drift, occasional rock knobs being found in places. The result is a system of numerous lakes and chains of lakes on the southern border of the county, near the Wisconsin line. These lakes form the head waters of the Ontonagon and Presque Isle rivers. This portion of the county is mostly covered with a heavy growth of timber.

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[1]Contribution 66 from the Department of Botany, Michigan Agricultural College

In August, 1919, Dr. Bessey and the writer made a botanical survey of the county, an attempt being made to examine the most characteristic floral regions. The work started August 6th in the lake region southwest of Watersmeet, with headquarters at Bent's camp on the south side of Mamie Lake, and less than a mile from the Wisconsin line. The entire township is covered with a chain of connecting lakes and of other lakes easily reached by portage. As before stated, the water in these lakes flows north, so that by throwing a dam across the outlet of one of the northern lakes it is possible to raise the water level in the entire chain. For the sake of easier navigation this has been done, but with the result of destroying much of the original shore line and its accompanying flora. The effect upon original stands of tamarack and arbor-vitae is a noteworthy example of this. In the shore-line association of trees these two species naturally stand first, evidently adapting themselves rather critically to the relative water content of the soil. Therefore, where the shore line has originally been somewhat flat, these species have occurred in larger stands than on steeper shore lines. Here it is that the rise of a few feet in the water level has been most destructive, leaving ugly patches of standing dead timber. Consequently, we found that isolated lakes, or those having no connection with the principal chain were best for the examination of aquatic or semi-aquatic vegetation, and for the study of true successional relationships in the flora.

Mamie Lake is typical of all the larger lakes of this region, which is more and more becoming the playground of vacationers from Illinois, Wisconsin and Michigan. This lake is a clear sheet of water covering nearly a square mile. Points anywhere along the shore are easily reached by canoe, and we found this the most convenient way of getting about in this lake region, unless one can have a motor boat or its equivalent. The surface of the lake region is in general undulating in character and heavily wooded. The valleys between the hills often dip down into sphagnum bogs. These are quite common, often forming open spaces in the forests. The entire region represents the dump moraine of a great glacier, one of whose arms extended over this area.

In the wooded area bodering Mamie Lake, the dominant trees are hemlock and yellow birch. In places these occur in nearly equal stands. Hemlock is the most conspicuous species in this lake region. We measured a specimen 40 inches in diameter 5 feet above the base. This species forms a zone of varying depth back from the shore line, the largest trees occupying the higher, better-drained soils. In places the yellow birch becomes almost dominant. In the region further north around Gogebic Lake, we found some very large specimens of this tree. In logged-over areas this species in the sapling stage, often accompanied with small white birch, sometimes takes the place of the usual aspen growth

Conspicuous in the beautiful green background of the lake shores are the spire-shaped tops of the balsams. We did not find this species in pure stands, but always mixed in with the hemlock and birch. Here and there along the low shores or around inland bogs the black spruce occurred, but not abundantly. Seedlings of this tree were commmon in sphagnum bogs. Occasional specimens of white spruce were found around Mamie Lake and vicinity, but this is evidently not common. Where the ground rises high

enough back of the coniferous zone lining the shores, a transition occurs to another association, embracing such trees as the sugar maple, basswood and American elm. Large specimens of yellow birch and hemlock are usually found scattered throughout this association. Here and there patches of hard maple occur in almost pure stands, with frequent areas of maple saplings or seedlings Farther north, in the vicinity of Gogebic Lake, the sugar maple is found in apparently virgin stands, covering many square miles. In this association, which is evidently nearing the climax condition, the basswood and American elm, in conformity with the maple, yellow birch and hemlock, become large trees. We measured a maple 37 inches in diameter, and a basswood 42 inches The beech was not seen at all. In the Mamie Lake region, as before stated, this forest aggregate occurs only on the higher ground and therefore forms a much smaller proportion of the total area than farther north in the Gogebic Lake region where it forms most of the wooded area. Of course, the relative proportion of the five species mentioned varies with different localities. In the most advanced stage of this association, I should say that the maple and basswood are the dominant species. This was the case around the Gogebic Lake region. There the trees are larger, making a comparatively deep shade, and hence a rather clear, open forest-floor Other trees observed in this connection were the ironwood (*Ostrya virginiana*) and the red osk (*Quercus rubra*). Both seem to be rare. The latter species was seen only once in the lake region.

Evidence shows that the red and white pine were formerly more abundant in the lake region than at present. Just how prominent these species were in former years was not determined Occasional large specimens of white pine were observed. One specimen on the upper reaches of the Slate River was 130 feet tall and measured 4 feet 7 inches in diameter. As a small tree or seedling it has now become an invader in the more open growth where soil conditions are favorable The red pine was less common. Only an occasional tree was seen in the lake region, and these were usually small.

We spent approximately two weeks at Bent's camp on the edge of the lake region. This was during the middle of August and too late for a part of the flora. A further examination of the many large lakes, both east and west of where we were stationed, will undoubtedly reveal several more species. A brief account of some of the commoner plant aggregates seen in this vicinity must suffice. An annotated list of all the plants seen in the county during the latter part of the summer of 1919 appears at the close of this paper.

There is a large range of variation in the condttions affecting aquatic vegetation, from the wind-swept surface of the larger lakes to the sheltered bays and shallow connecting arms between the lakes. At Mamie Lake, *Vallisneria spiralis*, *Potamogeton amplifolius* and *Potamogeton natans* occurred in rather exposed surfaces where the water was fairly deep, while *Potamogeton epihydrus*, *Potamogeton pusillus*, *Naias flexilis*, *Elodea canadensis*, *Ceratophyllum demersum* and *Myriophyllum spicatum* are good representatives of those aquatics found in quieter, more shallow water.

Among the floating-leaved type of rooting aquatics may be mentioned *Castalia tuberosa*, *Persicaria amphibia*, *Nymphaea advena* and *Brasenia schreberi*. The two former were sometimes found in comparatively deep

water. *Sagittaria latifolia* and *Pontederia cordata* were common on low muddy shores. Among other conspicuous plants occurring in similar situaitons were *Typha latifolia, Scirpus occidentalis, Eleocharis palustris* and various Sparganium species.

Mamie Lake is the most southern and by no means the largest of the chain of nine or ten lakes north of Bent's camp. Cisco Lake, across the outlet of which a dam has been thrown, is the most northerly of the chain. One of the isolated bodies of water we wished to examine was Mud Lake, a small body of water north of Mamie Lake, reached by portage from the latter. One of the interesting finds here was *Isoetes braunii.*

Lycopodium clavatum var. *monostachyon,* reported by Farwell from Keweenaw County, was common at one point along the low flat shore associated with *Lycopodium inundatum.* The water-shield, *Brasenia schreberi,* was common in this lake.

Sphagnum bogs are very numerous in the lake region, as well as in the ground moraine farther north. They occur either along the low margins of lakes or in open depressions in the forests. Leather leaf *Chamaedaphne calyculata* is the typical plant of such bogs. This is accompanied in varying degree with the ordinary bog plants, such as the pitcher plant, sundew, Labrador tea, *Kalmia polifolia, Carex pauciflora, Eriophorum virginicum,* etc.

The following trees and shrubs are often found on the low forest floor surrounding the lakes or bogs; *Acer rubrum,* common in the hemlock-birch associations and often accompanied by mountain maple, *Acer spicatum.* We found black ash frequently in swales in the woods. In the Mamie Lake region the trees were never large, but farther north in the Gogebic Lake region this species is quite common as a large forest tree. The mountain ash, *Sorbus americana,* was occasional in swampy woods and lake shores, and the seedlings occur in sphagnum bogs. *Cornus stolonifera* and *Alnus incana* were only occasional in the lake region. The latter shrub is exceedingly common in the cut-over region between Watersmeet and Marenisco.

On August 16th we made a side trip to the logged-over region between state line and Watersmeet in the eastern part of the county. Here we followed the right of way of the C. & N. W. Ry. for about nine miles, picking up many introduced species. The country here is gently rolling, with a secondary growth consisting largely of dominant aspens and young jack pine, with a varying proportion of pin cherry, young white pine, white spruce and balsam fir. In general, the soil was light, dry and characteristic of the so-called jack pine plains of the Lower Peninsula. Typical plants are the sweet fern, the bracken fern, *Diervilla diervilla, Padus nana* and *Salix humilis.* Occasional red pine and tamarack occur in places. Low spots were frequent with the corresponding bog vegetation.

After August 20th the country around Watersmeet was examined and then we moved westward to Gogebic Lake. In our three days' stay around Watersmeet we picked up additional introduced, as well as more native, species a few miles northeast of the town; but in general the country was similar to what has just been described.

On August 23d we moved to Gogebic Lake. This is by far the largest lake in the western part of the Upper Peninsula. It is about 12 miles long and varies from 1½ to 3 miles wide for the greater part of its length. Ap-

proximately half of the surface lies in Gogebic County and the remaining northern portion in Ontonagon County. The circumference of the lake is formed by sand beaches or terraces of boulder drift. The adjacent country south and west of the lake rises gradually several hundred feet to form a portion of the Gogebic Range, which extends to the western border of the state. Several streams feed the lake on this side. In their upper reaches these streams sometimes become quite swift and flow through deep, rocky gorges with beautiful waterfalls. One such stream we examined was Slate River, flowing in from the southwest. East of the lake the country is flatter, representing the ancient bed of a much larger lake. As stated previously, this section is covered with a dense growth of large timber, the sugar maple being the dominant species. Some of the typical plants of the rather dark, clear forest floor were occasional hazel, *Corylus rostrata*, *Caulophyllum thalictroides*, *Actaea alba*, *Lycopodium lucidulum*, *Carex intumescens*, *Cinna latifolia*, *Circaea alpina*, the oak fern, the beech fern, and *Polystichum braunii*.

While most of the shore of this lake is apparently low and flat, we found boulder drift in places where the shore line was quite abrupt. Here we found such plants as *Polypodium vulgare*, *Woodsia ilvensis* and *Selaginella rupestris*. Such a rocky formation is to be found on the west side of Slate River, where it flows into the lake. However, most of the lower portion of this tortuous little river is bordered for two or three miles by a semi-wooded swamp, mostly of black ash. Farther up, this is replaced by dense thickets of alder and red maple. Gradually the stream narrows, becomes clearer and swifter as it comes from the forest where its increasingly steep sides are bordered by such trees as hemlock, yellow birch, white spruce, elm, balsam fir and *Taxus canadensis*. Still further up we found the steep banks narrowing down into a rocky gorge for several hundred yards. In the rough forested area along the upper reaches of this stream, the following may be considered the typical plants: *Rubus parviflorus*, *Cornus alternifolia*, *Corylus rostrata*, *Sambucus racemosus*, *Aralia nudicaulis*, *Clintonia borealis*, and *Oxalis acetosella*. At the Gogebic Springs Hotel settlement where we were staying we picked up a few more introduced plants. In some respects, however, the flora of this region does not differ very materially from that found in the vicinity of Mamie Lake, except in those rocky formations which are associated with the Gogebic Range.

Believing that Bessemer and Ironwood on the west side would increase our list of introduced species, we decided to make a short side trip to that section. We spent parts of two days examining the flora in and around these two towns and on the rocky hills and outcrops nearby. We examined rather carefully just one of these many granite hills. A wide variation in ecological conditions may occur even in one hill, from sunny exposed southern slopes to the deep shade and moist soil of small wooded patches. We found, in part at least, a recapitulation of the cut-over and forest associations that we saw farther east. Near the base of the slope, where the soil was more or less disintegrated, *Populus tremuloides* was the dominant tree type. In ascending the steep, rocky slopes we encountered scattering white birch, pin cherry, *Padus nanus*, *Diervilla diervilla*, and the bracken fern with small elm and hard maple in the moister situations Small scraggly specimens of red oak were found in the talus slope, while *Antennaria*

neodioica, *Danthonia spicata*, and *Parthenocissus quinquefolia* were found in the exposed rock crevices. We were undoubtedly too late for several crucifers and early spring flowers. In the sheltered portions of this rocky outcrop we found small wooded areas where even the balsam flourished. The rocks are ideal for fern life. Here we found *Dryopteris fragrans*, *Filix fragilis* and *Asplenium trichomanes*. Dr. Bessey also found a specimen of *Malaxis unifolia* or green adder's mouth, one of our rare orchids. Our limited time did not allow us to make further investigations of these granite hills. Such examination would probably have given us some additional species, though, I think, the characteristic associations would have been about the same.

The following list comprises those species which were observed from August 6th to September 1st, 1919, throughout the region just described. It is too much to expect the list to be entirely free from errors:*

PTERIDOPHYTA (FERNS AND FERN ALLIES).

OPHIOGLOSSACEAE (ADDER'S TONGUE FAMILY).

Botrychium obliquum var. *oneidense* (Gilbert) Waters. In woods, upper reaches of the Slate River, near Gogebic Lake. Apparently rare.

Botrychium virginianum (L.) Sw. Rattlesnake fern. Occassional in rich woods. Lake region.

OSMUNDACEAE (ROYAL FERN FAMILY).

Osmunda regalis L. Royal Fern. Wet woods and swampy ground. Frequent throughout.

Osmunda cinnamomea L. Cinnamon Fern. Low ground. Occasional throughout.

Osmunda claytoniana L. Clayton's Fern Wood and low ground. More common than the preceding.

POLYPODIACEAE (FERN FAMILY).

Onoclea sensibilis L. Sensitive Fern. Occasional in swales throughout.

Matteuccia struthiopteris (L.) Todaro Ostrich Fern. Low ground throughout. Rather common.

Woodsia ilvensis (L.) R. Br. On rocks near Bessemer.

Filix fragilis (L.) Underw. Brittle Fern. Rather common in woods and rock outcrops in the Ironwood-Bessemer region.

Polypodium vulgare L. Common Polypody. Exposed rocks. Gogebic Lake. Bessemer.

Polystichum braunii (Spencer) Fee. Braun's Holly Fern. Frequent in woods near Geogebic Lake.

Dryopteris thelypteris (L.) A. Gray. Marsh Shield Fern. Common in wet, open soil throughout.

Dryopteris simulata Davenp. Dodge's Shield Fern. Swampy ground. Shore of Mamie Lake. Occasional.

*The nomenclature used here is that of the "Illustrated Flora of the Northern States and Canada," by Britton & Brown, 2d edition, 1913.

Dryopteris intermedia (Muhl.) Gray. American Shield Fern. The commonest species of fern in the lake region.

Dryopteris fragrans (L.) Schott. Fragrant Shield Fern. Shaded situations on rocky outcrops. Bessemer.

Dryopteris cristata (L.) A. Gray. Crested Shield Fern. Low ground throughout. Frequent in the Mamie Lake region.

Dryopteris phegopteris (L.) C. Chr. (Phegopteris polypodioides Fee). Beech Fern. Common in woods throughout.

Dryopteris dryopteris (L.) Britton. (Phegopteris dryopteris (L.) Fee.) Oak Fern. Woods, frequent throughout.

Asplenium trichomanes L. Maiden-hair Spleenwort. Rocky outcrops at Bessemer.

Athyrium filix-femina (L.) Roth. Lady Fern. Moist, shaded ground throughout. Common.

Athyrium thelypteroides (Michx.) Desv. Silvery Spleenwort. Woods along Slate River

Adiantum pedatum L. Maiden-hair Fern Occasional in maple woods throughout. Usually abundant where found.

Pteridium aquilinum (L.) Kuhn. Common Brake. Common in places, especially cleared land or old trails throughout.

EQUISETACEAE (HORSETAIL FAMILY)

Equisetum arvense L. Common Horsetail. Waste ground along railway embankments throughout.

Equisetum pratense Ehrh. Meadow Horsetail. Woods near Gogebic Lake.

Equisetum sylvaticum L. Wood Horsetail. Moist woods and wet ground along railway embankments throughout

Equisetum fluviatile L. Pipes. Boggy woods near Thousand Island Lake.

Equisetum hyemale L. Scouring Rush. Dry soil near Watersmeet. Apparently not common.

Equisetum scirpoides Michx. Moist woods, occasional. Lake region.

LYCOPODIACEAE (CLUB MOSS FAMILY).

Lycopodium lucidulum L. Shining Club-moss. Moist woods. Common throughout.

Lycopodium inundatum L. Marsh Club-moss. Low wet shore. Mud Lake

Lycopodium annotinum L. Stiff Club-moss. Deep moist woods. Common in the Mamie Lake region. Gogebic Lake.

Lycopodium clavatum L. Running Pine. Dry-shaded ground, occasional Mamie Lake region.

Lycopodium clavatum var *monostachyon* Grev. & Hook. Low wet short, Mud Lake. With *L. inundatum*.

Lycopodium obscurum L. Ground Pine Common in moist woods Throughout the lake region.

Lycopodium complanatum L. Trailing Christmas Green. Woods, common. Mamie Lake region.

SELAGINELLACEAE.

Selaginella rupestris (L.) Spring. Dwarf Club-moss. Dry exposed rocks. Gogebic Lake.

ISOETACEAE (QUILLWORT FAMILY).

Isoetes braunii Durien. Braun's Quillwort Shallow water, edge of Mud Lake. Not previously reported from Michigan, we believe.

SPERMATOPHYTA (SEED PLANTS).

PINACEAE (PINE FAMILY).

Pinus strobus L. White Pine. Stump evidence shows that this species was once common in the lake region. Only occasional large trees (80 to 100 feet tall), and no pure stands seen. Quite young trees are frequent, but scattered.

Pinus resinosa Ait. Red Pine. Mostly called "Norway pine" in Michigan. Quite scarce. The occasional trees seen were not large. This species has also been cut out

Pinus banksiana Lamb. "Jack Pine." Gray Pine. Common in the dry plains in the eastern part of the county near Watersmeet. Otherwise apparently scarce.

Larix laricina (Du Roi) Koch. Tamarack. Not common in the lake region, but probably more common in the ground moraine north.

Picea canadensis (Mill.) B.S.P. White Spruce. Frequent around the edge of lakes. Largest specimens seen 27 inches in diameter. This is apparently the commonest species of spruce in the Bessemer-Ironwood region. Not seen in pure stands. Mamie Lake region. Gogebic Lake.

Picea mariana (Mill) B S P. Black Spruce. Common in the lake region in low wet ground Seedlings common in sphagnum bogs in the woods.

Tsuga canadensis (L.) Carr. Hemlock. This is the dominant tree in the lake region, occurring in pure stands in places. In other situations it vies with yellow birch as the dominant species. Some very large specimens were seen The largest measured 40 inches in diameter 5 feet above the ground. The dead trunks of this tree seem to stand longer than other species where they have been killed out by flooding. Not so common in the western part of the county.

Abies balsamea (L.) Mill. Balsam. Common in the lake region where it is noticeable on account of the spire-shaped top, often projecting above the rest of the forest. In the ground moraine north this seems to be the commonest conifer It is associated with the alder and popple in the vast extent of logged-over land between Watersmeet and Marenisco. Largest specimen measured was 15 inches in diameter. Not seen in pure stands, but very widely distributed over the county.

Thuja occidentalis L. White Cedar. Arbor-vitae. Trees mostly small, especially those close to the water's edge. Frequent along the shores of lakes and in swales in woods, mixed with hemlock and yellow birch. No pure stands seen.

TAXACEAE (YEW FAMILY).

Taxus canadensis Marsh. American Yew. Frequent in deep, wet woods throughout. Eaten down by deer in places.

TYPHACEAE (CAT-TAIL FAMILY).

Typha latifolia L. Broad-leaved Cat-tail. Borders of lakes, common throughout.

SPARGANIACEAE (BUR-REED FAMILY).

Sparganium eurycarpum Engelm. Broad-fruiting Bur-reed. Shores of lakes Common.

Sparganium androcladum (Engelm.) Morong. Branching Bur-reed. Fish-hawk Lake.

Sparganium acaule (Beeby) Rydb. Stemless Bur-reed. Gogebic Lake; mouth of Eight-Mile Creek.

Sparganium fluctuans (Morong) Robinson. Floating Bur-reed Thousand Island Lake.

Sparganium minimum Fries. Small Bur-reed Vicinity of Gogebic Lake Shallow water. Apparently not common.

ZANNICHELLIACEAE (PONDWEED FAMILY).

Potamogeton natans L. Common Floating Pondweed. Frequent in the lake region.

Potamogeton oakesianus Robbins Oak's Pondweed. Sluggish open water three miles northeast of Watersmeet. Apparently not common

Potamogeton amplifolius Tuckerm. Large-leaved Pondweed. Mamie Lake Probably throughout

Potomogeton alpinus Balbis. Northern Pondweed. Three miles northeast of Watersmeet.

Potamogeton heterophyllus Schreb. Various-leaved Pondweed Thousand Island Lake. Probably throughout.

Potamogeton richardsonii (Benn.) Rydb. Mud Lake, near Bent's Camp. Also in Fish Hawk Lake.

Potamogeton obtusifolius Mert. & Koch Mamie Lake. Probably common throughout.

Potamogeton pusillus L. Small Pondweed. Lake region, common

Potamogeton filiformis Pers. Filiform Pondweed Vicinity of Gogebic Lake.

NAIADACEAE.

Naias flexilis (Willd.) Rost. & Schmidt. Mamie Lake region, shallow water

SCHEUCHZERIACEAE (ARROW-GRASS FAMILY).

Triglochin maritima L. Seaside Arrow-grass. Sphagnum bogs. Mamie Lake region. Occasional.

Scheuchzeria palustris L. Bogs in the lake region. Frequent.

ALISMACEAE (WATER-PLANTAIN FAMILY).

Alisma brevipes Greene. Western Water-plantain. In swampy ground. Vicinity of Gogebic Lake.

Sagittaria latifolia L. Arrow-head. Common along lake shores in shallow water. *Forma* GRACILIS (Pursh.) Robinson. Is also common and occurs with the broad-leaved variety.

VALLISNERIACEAE (TAPE-GRASS FAMILY).

Elodea canadensis Michx. Water-weed. Shallow water in the lake region.

Vallisneria spiralis L. Tape-grass. Rather common in the Mamie Lake region.

POACEAE (GRASS FAMILY).

Schizachyrium scoparium (Michx.) Nash. Broom Beard-grass. Dry land. Northeast of Watersmeet. Occasional.

Andropogon furcatus Muhl. Forked Beard-grass. Dry ground northeast of Watersmeet.

Syntherisma ischaemum (Schreb.) Nash. Small Crab-grass. Along C. & N. W. Ry. between State Line and Watersmeet. Ironwood.

Echinochloa crus-galli (L.) Beauv. Barnyard-grass. Bessemer. Occurs as a weed.

Panicum capillare L. Witch-grass. Dry, sandy soil, near Watersmeet. Ironwood.

Panicum miliaceum L Broom-corn Millet. Waste ground, Ironwood. Introduced.

Panicum boreale Nash. Northern Panic-grass. Moist, sandy ground, shore of Gogebic Lake.

Panicum xanthophysum Gray. Slender Panic-grass. Dry, sandy soil between State Line and Watersmeet.

Panicum clandestinum L. Corn-grass. Sandy soil between State Linc and Watersmeet.

Chaetochloa lutescens (Weigel) Stuntz. Yellow Fox-tail. Watersmeet. Waste ground at Bessemer. Not common.

Chaetochloa viridis (L.) Scribn. Green Fox-tail grass. Waste ground Watersmeet. Bessemer.

Homalocenchrus oryzoides (L.) Poll. Rice Cut-grass. Semi-shady situations along the shores of lakes.

Phalaris canariensis L. Canary-grass. Waste ground, Ironwood. Rare.

Anthoxanthum odoratum L. Sweet Vernal-grass. Around Gogebic Hotel settlement. Cisco Landing.

Milium effusum L. Tall Millet-grass. Woods near Gogebic Lake. Occasional.

Muhlenbergia foliosa Trin. Satin-grass. Low, moist, shaded ground. Vicinity of Gogebic Lake.

Muhlenbergia racemosa (Michx.) B.S.P Wild Timothy. In second growth on dry, burned-over area near Watersmeet.

Brachyelytrum erectum (Schreb) Beauv. Bearded Short-husk. Frequent in woods, Mamie Lake region. Gogebic Lake.

Phleum pratense L. Common Timothy. Escaped in places.

Alopecurus aristulatus Michx. Short-awned Foxtail. Wet ground northeast of Watersmeet. Occasional.

Cinna latifolia (Trev.) Griseb. Slender Wood-grass. The common species in the lake region. Throughout.

Agrostis alba L. White Bent. Moist, shaded ground, lake region. *A. alba* var. *vulgaris* or Red-top is found along roadside, etc.

Agrostis hyemalis (Walt.) B.S.P. Rough Hair-grass. Dry ground, Bessemer and near Watersmeet. Sometimes in wet soil on decaying logs, etc.

Agrostis perennans (Walt.) Tuckerm. The form called *A. schweinitzii* Trin. is commonest. Wet, shaded ground, Mamie Lake region. Gogebic Lake.

Calamagrostis canadensis (Michx.) Beauv. Blue-joint Grass. Common on low open ground around the shores of lakes. Throughout.

Avena sativa L. Oats. Escaped in places. Near Watersmeet.

Danthonia spicata (L.) Beauv. Common Wild Oat-grass. Dry ground, frequent. Bessemer. Watersmeet.

Phragmites phragmites (L.) Karst Common Reed-grass Wet ground, near Ironwood.

Eragrostis purshii Schrad. Pursh's Love-grass. Along R. R. track between State Line and Watersmeet.

Eragrostis major Host. Strong-scented Love-grass. Waste ground, Ironwood.

Dactylis glomerata L. Orchard-grass. Frequent throughout, near settlements.

Poa annua L. Dwarf Meadow-grass. Yards and waste places Throughout

Poa crocata Michx. Northern Spear-grass. Wet, open ground. Fish Hawk Lake. Occasional throughout.

Poa triflora Gilib. False Red-top. Frequent in wet ground.

Poa pratensis L. June-grass Common throughout, along roads, etc.

Poa compressa L. Canada Blue-grass Dry ground. Throughout. Less common than the preceding.

Panicularia canadensis (Michx.) Kuntze. Rattlesnake-grass. Borders of marshes, occasional. Cisco Lake Gogebic Lake.

Panicularia nervata (Willd.) Trin. Nerved Manna-grass. Usually in moist, partially-shaded ground. Frequent throughout.

Panicularia grandis (S. Wat.) Nash. Reed Meadow-grass. Wet ground, occasional. Northeast of Watersmeet.

Panicularia pallida (Torr.) Trin Pale Manna-grass. Occasional on muddy shores. Thousand Island Lake.

Panicularia pallida var. *fernaldii* Hitchc. Same habitat as preceding. Northeast of Watersmeet.

Festuca ovina var. *hispidula* Hack. Sheep's Fescue-grass. Open sandy shore of Gogebic Lake.

Festuca elatior L. Tall Fescue-grass. Waste ground, frequent throughout Gogebic Lake.

Bromus kalmii A. Gray. Kalm's Chess. Near Watersmeet.

Bromus ciliatus L. Wood Cheat. Waste ground, occasional. Between State Line and Watersmeet.

Agropyron repens (L) Beauv. Quack-grass. Waste places. Watersmeet. Bessemer. One of the worst weeds in the state.

Agropyron tenerum Vasey. Slender Wheat-grass. Dry ground Between State Line and Watersmeet.

Agropyron caninum (L.) R. & S. Bearded Wheat-grass. Same habitat and locality as preceding.

Secale cereale L. Rye. Escaped in places. Along C. & N. W. Ry, near Watersmeet.

Hordeum jubatum L. Squirrel-tail Grass. Waste ground. Watersmeet. Bessemer.

Elymus virginicus L. Terrell-grass. Moist, shaded ground. Near Watersmeet.

Hystrix hystrix (L.) Millsp. Bottle-brush Grass. Gogebic Lake. Apparently not common.

CYPERACEAE (SEDGE FAMILY).

Eleocharis obtusa (Willd.) Schultes. Blunt Spike-rush. Wet soil, vicinity of Gogebic Lake.

Eleocharis palustris (L.) R. & S. Creeping Spike-rush. Frequent on muddy shores throughout.

Eriophorum virginicum L. Virginia Cotton-grass. Sphagnum bogs, common. Mamie Lake. Probably throughout.

Scirpus occidentalis (Wats.) Chase. Great Bulrush. In water, borders of lakes, occasional. Mamie Lake. Gogebic Lake.

Scirpus atrovirens Muhl. Dark-green Bulrush. Wet ground. Gogebic Lake.

Scirpus cyperinus (L) Kunth. Wool-grass. Wet soil, common. Thousand Island Lake. Gogebic Lake.

Scirpus atrocinctus Fernald Between State Line and Watersmeet.

Dulichium arundinaceum (L.) Britton. Dulichium. Common along lake shores.

Rynchospora alba (L.) Vahl. White Beaked-rush. Sphagnum bog, frequent. Mamie Lake. Cisco Lake.

Carex chordorhiza Ehrh. Creeping Sedge. Sphagnum bog near Bass Lake.

Carex vulpinoidea Michx. Fox Sedge. Wet soil. Near Watersmeet. Apparently not common.

Carex trisperma Dewey. Three-fruited Sedge. Low, wet ground in woods. Common throughout.

Carex brunnescens (Pers.) Poir. Damp ground. Thousand Island Lake. Mud Lake. Probably throughout.

Carex crawfordii var. *vigens* Fernald. Crawford's Sedge. Deep moist woods. Cisco Lake.

Carex projecta Mackenzie. Necklace Sedge. Damp ground. Thousand Island Lake.

Carex bebbii Olney. Bebb's Sedge. Low ground. Fish Hawk Lake.

Carex leptalea Wahl. Bristle-stalked Sedge. Low wet ground in woods. Common throughout.

Carex pauciflora Lightf. Few-flowered Sedge. Sphagnum swamps. Frequent throughout.

Carex communis Bailey. Fibrous-rooted Sedge. Woods. Gogebic Lake. On rotting logs.

Carex gracillima Schwein. Graceful Sedge. Wet soil in woods. Mamie Lake.

Carex arctata Boott. Drooping Wood Sedge. Woods, frequent throughout.

Carex limosa L. Mud Sedge. Sphagnum bogs. Cisco Lake.

Carex paupercula Michx. Bog Sedge. Frequent in sphagnum bogs throughout.

Carex gynandra Schwein. Nodding Sedge. Wet ground between State Line and Watersmeet. Frequent.

Carex lasiocarpa Ehrh. Slender Sedge. Wet ground in the lake region. Frequent.

Carex houghtonii Torr. Houghton's Sedge. Dry, sandy soil. Northeast of Watersmeet.

Carex monile Tuckerm. Necklace Sedge. Occasional in wet ground. Gogebic Lake.

Carex rostrata Stokes. Beaked Sedge. Marshy ground. Thousand Island Lake. Gogebic Lake. Frequent.

Carex tuckermani Dewey. Tuckerman's Sedge. Wet ground, usually somewhat shaded. Gogebic Lake. Thousand Island Lake. Usually occurs plentifully where found.

Carex retrorsa Schwein. Marshy ground, frequent. Near Watersmeet. Gogebic Lake.

Carex oligosperma Michx. Few-seeded Sedge. Sphagnum bogs, common Mamie Lake. Gogebic Lake.

Carex pseudo-cyperus L. Cyperus-like Sedge. Wet soil, occasional. Mamie Lake.

Carex comosa Boott. Bristly Sedge. Marshy ground, occasional. Bass Lake

Carex intumescens Rudge. Bladder Sedge. Wet woods. Common throughout.

Carex lupulina Muhl Hop Sedge. Shore of Gogebic Lake, apparently not common.

ARACEAE (ARUM FAMILY).

Arisaema triphyllum (L.) Torr. Jack-in-the-Pulpit. Deep woods, occasional throughout. Thousand Island Lake. Gogebic Lake. Bessemer-Ironwood region.

Calla palustris L. Water Arum. Borders of lakes. Throughout.

LEMNACEAE (DUCKWEED FAMILY)

Spirodela polyrhiza (L.) Schleid Greater Duckweed. Occasional in shallow water. Fish Hawk Lake, etc.

Lemna trisulca L. Ivy-leaved Duckweed One place four miles northeast of Watersmeet.

Lemna minor L. Lesser Duckweed. Frequent in still water throughout.

PONTEDERIACEAE (PICKEREL-WEED FAMILY).

Pontederia cordata L. Pickerel Weed. Frequent on the shores of ponds, often forming large patches. Lake region.

JUNCACEAE (RUSH FAMILY).

Juncus effusus L. Common Rush. Frequent in moist open ground throughout.

Juncus filiformis L. Thread Rush. Occasional in wet soil. Margin of Mud Lake.

Juncus bufonius L. Toad Rush. In clay soil along C. & N. Ry., near Watersmeet. Gogebic Lake.

Juncus tenuis Willd. Wire-grass. Dry ground. Watersmeet. Occurs as a weed around settlements.

Juncus nodosus L. Knotted Rush. Northeast of Watersmeet. Apparently not common.

Juncus brevicaudatus (Engelm.) Fernald. Narrow-panicled Rush. Apparently the commonest species in the lake region. Wet ground, borders of lakes.

LILIACEAE (LILY FAMILY).

Allium canadense L. Meadow Garlic. Low woods. Gogebic Lake.

CONVALLARIACEAE (LILY-OF-THE-VALLEY FAMILY).

Clintonia borealis (Ait.) Raf. Wet woods, common throughout.

Vagnera racemosa (L.) Morong False Spikenard. Occasional in the lake region. Commoner in the Bessemer-Ironwood region.

Unifolium canadense (Desf.) Greene. False Lily-of-the-Valley. Mossy banks in moist woods Common throughout.

Streptopus roseus Michx. Twisted-stalk. Maple woods. Commoner in the western part of the county.

TRILLIACEAE (WAKE-ROBIN FAMILY).

Trillium grandiflorum (Michx.) Salisb. Large-flowered Trillium. Common in the Gogebic Range. Otherwise apparently scarce.

Trillium cernuum L. Nodding Wake-robin. Frequent in maple woods throughout.

SMILACEAE (SMILAX FAMILY).

Smilax ecirrhata (Engelm.) S. Wats. Upright smilax. Woods near Gogebic Lake. Occasional.

IRIDACEAE (IRIS FAMILY).

Iris versicolor L. Larger Blue-flag. Frequent in wet ground throughout.

ORCHIDACEAE (ORCHID FAMILY).

Fissipes acaulis (Ait.) Small. Stemless Ladies'-slipper. Sphagnum bogs throughout. Frequent. Lake region.

Coeloglossum bracteatum (Willd.) Parl. Long-bracted Orchis. Deep woods. Bass Lake. Not common.

Gymnadeniopsis clavellata (Michx.) Rydb. Small Green Wood Orchis. Common at Mud Lake.

Limnorchis hyperborea (L.) Rydb. Tall Leafy Green Orchis. Deep, wet woods northeast of Watersmeet. Probably throughout.

Limnorchis dilatata (Pursh.) Rydb. Tall White Bog Orchis. Sphagnum bog near Bass Lake. Occasional.

Lysiella obtusata (Pursh.) Richards. Small Northern Bog Orchis. Deep woods Cisco Lake Gogebic Lake. Occasional.

Arethusa bulbosa L. Dragon's Mouth. Sphagnum bog. Cisco Lake.

Ibidium strictum (Rydb.) House. Hooded Ladies'-Tresses. Wet soil. Bass Lake. Near Watersmeet.

Ibidium cernuum (L.) House. Nodding Ladies'-Tresses. Near Watersmeet. Wet soil.

Ibidium gracile (Bigel.) House. Slender Ladies'-Tresses. Dry hillside, gravelly soil. Near Watersmeet.

Peramium ophioides (Fernald) Rydb. Lesser Rattlesnake Plantain. Woods, frequent.

Malaxis unifolia Michx. Green Adder's Mouth. Rocky outcropping at Bessemer, under trees. One of Michigan's rarest orchids.

Corallorrhiza maculata Raf. Large Coral-root. Apparently the commonest species. Frequent. Thousand Island Lake. Often in soil containing rotting wood.

MYRICACEAE (BAYBERRY FAMILY).

Myrica gale L. Sweet Gale. Common in places along shores of lakes, forming large patches. Throughout.

Comptonia peregrina (L.) Coulter. Sweet Fern. Dry soil, south of Watersmeet. Very common in places on the Jack-pine plains.

SALICACEAE (WILLOW FAMILY).

Populus balsamifera L. Balsam Poplar. Dry soil, near Watersmeet Infrequent.

Populus grandidentata Michx. Large-toothed Aspen. Woods, especially, cleared land throughout. Found in drier situations than the following.

Populus tremuloides Michx. American Aspen. Common on logged-over land. Throughout.

Populus dilatata Ait. Lombardy Poplar. Bessemer.

Salix lucida Muhl. Shining Willow. Wet ground, northeast of Watersmeet. Frequent in the Bessemer-Ironwood region.

Salix interior Rowlee. Sandbar Willow. Low ground near Watersmeet

Salix cordata Muhl. Diamond Willow. Wet soil, between Watersmeet and State Line. Probably throughout.

Salix petiolaris J. E Smith. Slender Willow. Low ground throughout

Salix bebbiana Sarg. Beaked Willow. Dry or moist soil. Frequent throughout.

Salix discolor Muhl Pussy Willow Low ground between Watersmeet and State Line in the Ironwood-Bessemer region.

Salix humilis Marsh. Prairie Willow Frequent on Jack Pine plains near Watersmeet.

Salix pedicellaris Pursh. Bog Willow. Sphagnum bogs. Frequent

BETULACEAE (BIRCH FAMILY).

Ostrya virginiana (Mill.) Willd. Hop-hornbeam. Woods near Fish Hawk Lake. Also in the western part of the county. Apparently infrequent. Measured one specimen 14 inches in diameter.

Corylus rostrata Ait. Beaked Hazel-nut. Woods, common. Mamie Lake region. Gogebic Lake The common species in the Upper Peninsula.

Betula papyrifera Marsh. Paper or Canoe Birch. Very common in the lake region where it apparently occurs in pure stands in the sapling stage Closer inspection of these stands usually shows a few yellow birch mixed in. No very large trees seen, as was the case with Yellow Birch

Betula lutea Michx. Yellow Birch. One of the commonest of large trees in the lake region, where it becomes the dominant species in places Often occurs in almost pure stands in the sapling stage on logged-over land.

Alnus incana (L.) Moench. Speckled Alder. Common in places, especially along streams. Intolerant of too much shade. Very common along C. & N. W. Ry. right of way between Watersmeet and Marenisco. Throughout.

FAGACEAE (BEECH FAMILY).

Quercus rubra L. Red Oak. Rare in the lake region. Rocky outcrops at Bessemer and Ironwood.

ULMACEAE (ELM FAMILY).

Ulmus americana L. American or White Elm. Occasional throughout. Occurs as a large tree in the forests with sugar maple, yellow birch, hemlock and basswood.

CANNABINACEAE (HEMP FAMILY).

Humulus lupulus L. Hop. Open thickets near Watersmeet. Also in the Bessemer-Ironwood region. Occasional.

URTICACEAE (NETTLE FAMILY).

Urtica dioica L. Stinging Nettle. Waste ground at Ironwood. Rare.

Urtica gracilis Ait. Slender Nettle. Dry ground near Watersmeet. The common species in Michigan

Urticastrum divaricatum (L.) Kuntze. Rich ground throughout. Occasional.

LORANTHACEAE (MISTLETOE FAMILY).

Razoumofskya pusilla (Peck.) Kuntze. Small Mistletoe. Occasional in bog forest on *Picea mariana*. Gogebic Lake.

ARISTOLOCHIACEAE (BIRTHWORT FAMILY)

Asarum canadense L Wild Ginger. Rich woods near Gogebic Lake. Also in the Bessemer-Ironwood region Not common.

POLYGONACEAE (BUCKWHEAT FAMILY).

Rumex acetosella L. Sheep Sorrel. This naturalized weed is found in many places comparatively far from any settlements. Throughout.

Rumex mexicanus Meisn. Willow-leaved Dock. Rich soil near Gogebic Lake. Bessemer. Introduced.

Rumex verticillatus L. Swamp Dock. Occasional in swamps. Throughout.

Rumex britannica L. Great Water Dock. Wet soil northeast of Watersmeet. Seen at one place only.

Rumex crispus L. Curled Dock. Yellow Dock. Waste ground throughout. Introduced weed.

Rumex obtusifolius L Broad-leaved Dock. Occasional in waste ground throughout.

Rumex persicarioides L. Golden Dock Near Ironwood. Seen at one place only.

Polygonum aviculare L. Knot-grass. Around settlements, Watersmeet, Bessemer, etc.

Polygonum erectum L. Erect Knotweed. Watersmeet. Bessemer.

Persicaria amphibia (L.) S. F. Gray. Willow-weed. Mamie Lake. In comparatively deep water. Rather scarce. Probably throughout.

Persicaria muhlenbergii (S. Wats.) Small. Swamp Persicaria. Muddy shores, occasional. Fish Hawk Lake Gogebic Lake.

Persicaria persicaria (L.) Small. Lady's Thumb Waste ground, Watersmeet and Bessemer. Introduced weed

Persicaria pennsylvanica (L.) Small. Moist soil, near Watersmeet and Bessemer.

Persicaria punctata (Ell) Small. Water Smart-weed. Wet ground, frequent, Lake region.

Fagopyrum fagopyrum (L.) Karst Buckwheat. Waste ground Ironwood

Tracaulon sagittatum (L.) Small. Arrow-leaved Tear-thumb Wet soil Cisco Lake. Ironwood.

Tiniaria convolvulus (L.) Webb & Moq Black Bindweed. Waste ground near Watersmeet. Bessemer. Occasional.

Tiniaria cilinodis (Michx.) Small. Fringed Bindweed. Borders of woods throughout. The stems of this plant evidently become coarser and reddish colored in open cleared land.

AMARANTHACEAE (AMARANTH FAMILY)

Amaranthus retroflexus L Red Root. Waste ground, throughout.

Amaranthus blitoides S Wats Prostrate Amaranth. Watersmeet.

Amaranthus graecizans L Tumble-weed. Wast ground. Watersmeet.

CHENOPODIACEAE (GOOSEFOOT FAMILY)

Chenopodium album L. Lamb's Quarters Waste ground, throughout Introduced weed

Chenopodium glaucum L. Oak-leaved Goosefoot. Streets of Watersmeet Ironwood. Introduced weed.

Blitum capitatum L. Strawberry Blight. Waste ground at Bessemer

Salsola pestifer A. Nelson Russian Thistle. Ironwood Not common Introduced from abroad

AIZOACEAE (CARPET-WEED FAMILY)

Mollugo verticillata L. Carpet-weed Waste ground Ironwood.

ALSINACEAE (CHICKWEED FAMILY)

Alsine media L. Common Chickweed. Waste ground Watersmeet. Bessemer.

Cerastium vulgatum L. Mouse-ear Chickweed. Meadows and waste ground throughout.

Spergula arvensis L. Spurrey. Roadsides. Occasional. Near Watersmeet. Gogebic Lake. Ironwood. Waste ground. Introduced weed

CARYOPHYLLACEAE (PINK FAMILY).

Agrostemma githago L. Corn Cockle. Waste ground. Watersmeet.

Silene noctiflora L. Night-flowering Catchfly. Waste ground. Near Watersmeet. Bessemer.

Lychnis alba Mill. White Campion. Waste ground. Near Watersmeet

Saponaria officinalis L. Bouncing Bet. Waste ground. Bessemer.

CERATOPHYLLACEAE (HORNWORT FAMILY).

Ceratophyllum demersum L. Hornwort. Shallow water in the lake region. Common.

CABOMBACEAE (WATER-SHIELD FAMILY).

Brasenia schreberi Gmel. Water-shield. Frequent in lakes. Mud Lake. Mamie Lake.

NYMPHAEACEAE (WATER LILY FAMILY).

Nymphaea advena Soland Large Yellow Pond Lily. Common in the lake region. *Nymphaea advena* var. *variegata* occurs in Mud Lake.

Castalia tuberosa (Paine) Greene. White Water Lily. Common in the lake region.

Castalia odorata (Dryand.) Woodv. & Wood. Sweet-scented Water Lily. In Morley Lake. Evidently not common.

RANUNCULACEAE (CROWFOOT FAMILY).

Caltha palustris L. Marsh Marigold Common along lake shores and edges of bogs throughout.

Coptis trifolia (L.) Salisb. Gold-thread. Common mossy banks in moist woods. Throughout

Actaea rubra (L.) Mill. Red Baneberry Moist, shaded ground. Near Watersmeet. Infrequent.

Actaea alba (L.) Mill. White Baneberry Woods throughout. Frequent.

Aquilegia canadensis L. Wild Columbine Frequent throughout Common in rocky woods of the Gogebic Range

Anemone virginiana L. Tall Anemone. Dry woods. Near Watersmeet Occasional.

Anemone canadensis L. Round-leaved Anemone Low ground throughout Frequent.

Hepatica hepatica (L.) Karst Liver-leaf Near Gogebic Lake Also in the Bessemer-Ironwood region. Not common

Ranunculus purshii Richards Pursh's Buttercup Wet soil. Gogebic Lake.

Ranunculus sceleratus L. Cursed Crowfoot. Introduced at Ironwood

Ranunculus recurvatus Poir. Rough Crowfoot. Frequent in wet woods throughout.

Ranunculus acris L. Meadow Buttercup. Introduced at Watersmeet. Gogebic Lake and Bessemer.

Ranunculus pennsylvanicus L. Bristly Crowfoot. Occasional in wet, open ground. Cisco Lake.

Ranunculus septentrionalis Poir. Marsh Buttercup. Occasional in wet ground and low woods throughout.

Batrachium trichophyllum (Chaix.) F. Schultz. Water Crowfoot. Muddy ponds near Watersmeet.

Batrachium circinatum (Sibth.) Rchb. Stiff Water Crowfoot. Shallow ponds near Watersmeet.

Thalictrum dioicum L. Early Meadow Rue. Moist woods near Bass Lake.

Thalictrum polygamum Muhl. Tall Meadow Rue. Low rich ground throughout.

Clematis virginiana L. Virgin's Bower. Frequent in dry soil, especially along railway embankments.

BERBERIDACEAE (BARBERRY FAMILY).

Caulophyllum thalictroides (L.) Michx. Blue Cohosh. Occasional in rich maple woods. Around Gogebic Lake and in the Gogebic Range

FUMARIACEAE (FUMEWORT FAMILY).

Capnoides sempervirens (L.) Borck Pink Corydalis. Occasional on rocky outcrops of the Gogebic Range

Capnoides aureum (Willd.) Kuntze. Near Watersmeet, along C. & N. W. track. Had the appearance of being introduced.

BRASSICACEAE (MUSTARD FAMILY)

Bursa bursa-pastoris (L.) Britt Shepherd's Purse. Waste ground throughout. Occasionally found some distance from settlements

Radicula palustris (L) Moench Yellow Water-cress Low ground between State Line and Watersmeet Ironwood. Probably throughout

Armoracia armoracia (L.) Britton Horse-radish. Escaped from cultivation in places. Ironwood, etc.

Lepidium densiflorum Schrad Wild Pepper-grass. Along C & N. W. Ry, between State Line and Watersmeet. Bessemer

Erysimum officinale L. Hedge Mustard. Waste ground. Ironwood Introduced

Norta altissima (L) Britton. "Jim Hill Mustard." Near Watersmeet Bessemer. Introduced. Not yet common.

Arabis glabrata (L.) Bernh. Tower Mustard Dry ground between State Line and Watersmeet.

Sinapis arvensis L. Charlock Frequent around settlements. Introduced weed.

Brassica juncea (L) Cosson. Indian Mustard Along C. & N W. Ry, between State Line and Watersmeet.

SARRACENIACEAE (PITCHER-PLANT FAMILY).

Sarracenia purpurea L. Pitcher-plant. Sphagnum bogs, frequent

DROSERACEAE (SUNDEW FAMILY).

Drosera rotundifolia L. Sundew. Eyebright Sphagnum bogs and low shores. Frequent throughout.

SAXIFRAGACEAE (SAXIFRAGE FAMILY).

Tiarella cordifolia L Coolwort. Woods Gogebic Lake.

Mitella nuda L. Bishop's Cup. Low, wet ground in woods. Frequent in the lake region.

Chrysosplenium americanum Schwein. Golden Saxifrage. Occasional in small streams throughout.

ANACARDIACEAE (SUMAC FAMILY).

Toxicodendron radicans (L.) Kuntze. Poison Ivy. Rich soil. Gogebic Lake. Near Bessemer. Not common.

Rhus hirta (L.) Sudw. Staghorn Sumac. Vicinity of Mamie Lake. Occasional in dry soil throughout.

ILICACEAE (HOLLY FAMILY).

Ilex verticillata (L.) A. Gray. Winterberry. Black Alder. Swampy woods, Bass Lake. Infrequent. Probably throughout.

Nemopanthus mucronata (L.) Trelease. Cat-berry. Swampy woods and sphagnum bogs. Occasional throughout.

CELASTRACEAE (STAFF-TREE FAMILY).

Celastrus scandens L. Shrubby Bittersweet. Rich soil. Occasional in the lake region.

ACERACEAE (MAPLE FAMILY).

Acer rubrum L Red Maple. Swamps and low ground. Common throughout. Often occurs with mountain maple.

Acer saccharum Marsh. Sugar Maple Common. The most valuable tree of the climax forests. Throughout.

Acer spicatum Lam. Mountain Maple. Common in damp forest openings or lake shores. Throughout.

Acer negundo L. Box Elder Ironwood.

RHAMNACEAE (BUCKTHORN FAMILY).

Rhamnus alnifolia L'Her. Alder-leaved Buckthorn. Swampy woods northeast of Watersmeet. Infrequent. Probably throughout.

VITACEAE (GRAPE FAMILY).

Parthenocissus quinquefolia (L.) Planch. Virginia Creeper. Gogebic Lake. Rocky outcrops of the Gogebic Range. Infrequent.

TILIACEAE (BASSWOOD FAMILY).

Tilia americana L. Basswood. American Linden. A common tree of the climax forests. Very large trees in the vicinity of Gogebic Lake.

MALVACEAE (MALLOW FAMILY)

Malva rotundifolia L. Low Mallow. Waste ground at Bessemer. Introduced.

HYPERICACEAE (ST. JOHN'S WORT FAMILY).

Hypericum ascyron L. Great St. John's Wort. Low ground between State Line and Watersmeet. Not common, but usually quite abundant when found.

Hypericum ellipticum Hook. Pale St. John's Wort. Borders of lakes. Frequent.

Hypericum boreale (Britton) Bicknell. Northern St. John's Wort. Wet soil in the lake region. Frequent.

Hypericum mutilum L. Dwarf St John's Wort. Low ground between State Line and Watersmeet.

Triadenum virginicum (L.) Raf. Marsh St. John's Wort Wet ground, frequent.

VIOLACEAE (VIOLET FAMILY)

?*Viola renifolia* A. Gray. Rich woods, Mamie Lake. Not found in flower.

Viola blanda Willd Sweet White Violet. Moist woods. Common in the lake region.

Viola pallens (Banks) Brainerd Northern White Violet In quite wet ground. Borders of lakes and low woods throughout.

Viola pubescens Ait. Downy Yellow Violet Dry, open woods, near Watersmeet.

Viola subvestita Greene. Sand Violet. Dry, open ground along C & N W. Ry., between State Line and Watersmeet. Formerly called *V. arenaria* D. C.

THYMELAEACEAE (MEZEREUM FAMILY)

Dirca palustris L. Leather-wood. Frequent in wet woods, but not abundant at any one spot Throughout

LYTHRACEAE (LOOSESTRIFE FAMILY).

Decodon verticillatus (L.) Ell. Swamp Loosestrife In shallow water, border of Mamie Lake. Occurs in large clumps.

ONAGRACEAE (EVENING PRIMROSE FAMILY)

Chamaenerion angustifolium (L.) Scop. Fire-weed. Frequent in low ground, following fires.

Epilobium coloratum Muhl. Purple leaved Willow Herb. Frequent in low ground in the lake region.

Epilobium adenocaulon Haussk. Northern Willow Herb Moist ground in the lake region.

Oenothera biennis L. Common Evening Primrose. Dry ground, near Watersmeet. Bessemer.

Circaea alpina L. Smaller Enchanter's Nightshade. Moist woods, common throughout.

HALORAGIDACEAE (WATER-MILFOIL FAMILY).

Myriophyllum spicatum L. Water-milfoil. Shallow water, Mamie Lake Probably throughout.

ARALIACEAE (GINSENG FAMILY).

Aralia racemosa L. American Spikenard. Gogebic Lake. Occasional.

Aralia nudicaulis L. Wild Sarsaparilla. Common in rich woods throughout.

Aralia hispida Vent. Bristly Sarsaparilla. Dry ground along C. & N W. Ry., near Watersmeet.

AMMIACEAE (CARROT FAMILY).

Washingtonia claytoni Britton. Sweet Cicely. Gogebic Lake. Very common in rich woods of the Gogebic Range

Heracleum lanatum Michx. Cow-parsnip. Frequent in the western part of the county. Occasional elsewhere.

Sium cicutaefolium Schrank. Hemlock Water-parsnip. Swampy woods in the lake region. Not common. Thousand Island Lake. Gogebic Lake.

Cicuta bulbifera L. Slender Water Hemlock. Wet ground, occasional throughout.

CORNACEAE (DOGWOOD FAMILY).

Cornus stolonifera Michx. Red-osier Dogwood. Mostly in open, damp ground. Not very common in the lake region.

Cornus alternifolia L. Alternate-leaved Dogwood. Frequent throughout.

Cornus canadensis L. Dwarf Cornel. Common in moist woods throughout.

PYROLACEAE (WINTERGREEN FAMILY).

Pyrola elliptica Nutt. Shin-leaf Deep woods along upper reaches of Slate River.

Pyrola secunda L. One-sided Wintergreen. Moist woods. The commonest species.

Moneses uniflora (L.) A Gray. One-flowered Wintergreen Near Bass Lake. Gogebic Lake. Occasional.

Chimaphila umbellata (L.) Nutt. Pipsissewa. Near Cisco Lake. Occasional.

MONOTROPACEAE (INDIAN PIPE FAMILY).

Monotropa uniflora L. Indian Pipe. Damp, rich woods in the lake region. Frequent.

Hypopitys lanuginosa (Michx.) Nutt. Hairy Pine-sap. Shore of Mud Lake. Infrequent.

ERICACEAE (HEATH FAMILY).

Ledum groenlandicum Oeder. Labrador Tea. In sphagnum bogs. Common throughout.

Kalmia polifolia Wsng. Swamp Laurel. Sphagnum swamps throughout.

Chamaedaphne calyculata (L.) Moench. Leather-leaf. One of the commonest of bog plants, often covering large areas.

Andromeda glaucophylla Link. Wild Rosemary. Sphagnum bogs, frequent threughout.

Epigaea repens L. Trailing Arbutus. Shaded situations, usually in sandy soil, near Watersmeet. Occasional throughout.

Gaultheria procumbens L. Checkerberry. Dry woods. Occasional in sphagnum bogs. Throughout.

VACCINIACEAE (HUCKLEBERRY FAMILY).

Vaccinium canadense Kalm. Canada Blueberry. Sphagnum bogs throughout.

Vaccinium angustifolium Ait. Low-bush Blueberry. Dry, open ground, near Watersmeet. Also near Gogebic Lake.

Chiogenes hispidula (L.) T. & G. Creeping Snowberry. Boggy woods, common, especially on rotting wood.

Oxycoccus oxycoccus (L.) MacM. Small Cranberry. Sphagnum bogs and shores of lakes. Frequent. Cisco Lake. Mud Lake.

Oxycoccus macrocarpus (Ait.) Pursh. Large Cranberry Edge of Mud Lake. Apparently not so common as the previous species.

PRIMULACEAE (PRIMROSE FAMILY).

Lysimachia terrestris (L.) B S. P. Bulb-bearing Loose-Strife. Wet woods, Cisco Lake.

Steironema lanceolatum (Wait.) A. Gray. Low, wet ground, frequent throughout. Fish Hawk Lake.

Trientalis americana Pursh. Star-flower. Damp woods. Frequent throughout.

OLEACEAE (OLIVE FAMILY).

Fraxinus nigra Marsh. Black Ash The common species in Gogebic County. Abundant near Gogebic Lake. Low, wet woods throughout.

GENTIANACEAE (GENTIAN FAMILY).

Dasystephana grayi (Kusnezow) Britton. Gray's Gentain. Low ground, along C. & N. W. Ry., between State Line and Watersmeet. Abundant at this point.

Halenia deflexa (J. E. Smith) Griseb. Spurred Gentian Moist woods, shore of Gogebic Lake.

MENYANTHACEAE (BUCKBEAN FAMILY).

Menyanthes trifoliata L. Buckbean. Wet woods and lake shores. Occasional. Thousand Island Lake.

APOCYNACEAE (DOGBANE FAMILY).

Apocynum androsaemifolium L. Spreading Dogbane. Along C. & N. W Ry., near Watersmeet. Frequent in dry soil.

CONVOLVULACEAE (MORNING GLORY FAMILY).

Convolvulus spithamaeus L. Low Bindweed. Frequent along railway tracks in dry soil.

BORAGINACEAE (BORAGE FAMILY)

Cynoglossum officinale L. Hound's Tongue. Frequent in waste ground near Ironwood and Bessemer. Introduced.

VERBENACEAE (VERVAIN FAMILY).

Verbena urticifolia L. White Vervain. Waste ground near Gogebic Springs Hotel settlement. Not common.

Verbena hastata L. Blue Vervain. Moist ground near Watersmeet. Gogebic Lake. Not Common.

LABIATAE (MINT FAMILY).

Teucrium canadense L. American Germander. Shore of Gogebic Lake.

Scutellaria lateriflora L. Mad-dog Scull cap. Common, along muddy shores. Throughout.

Scutellaria galericulata L. European Scull cap. Occasional in wet places.

Glecoma hederacea L. Ground Ivy. Waste ground. Ironwood.

Moldavica parviflora (Nutt.) Britt. American Dragon-head. One specimen along C. & N. W. Ry., near Watersmeet.

Prunella vulgaris L. Self-heal. Along C. & N. W. Ry., near Watersmeet. Bessemer.

Galeopsis tetrahit L. Hemp Nettle. Waste ground near Watersmeet. Ironwood.

Stachys palustris L. Hedge Nettle. Moist ground near Gogebic Lake.

Satureia hortensis L. Summer Savory. Waste ground at Ironwood.

Clinopodium vulgare L. Field Basil. Frequent on dry bluffs of the Gogebic Range.

Lycopus uniflorus Michx. Northern Bugle-weed. Frequent along lake shores. Apparently the commonest species.

Mentha canadensis L. American Wild Mint. Moist soil in the lake region. Frequent.

SOLANACEAE (POTATO FAMILY).

Solanum nigrum L. Black Nightshade. Waste ground at Bessemer.

Solanum rostratum Dunal. Buffalo-bur. Introduced.

SCROPHULARIACEAE (FIGWORT FAMILY).

Verbascum thapsus L. Great Mullein. Waste ground. Occasional. Near Watersmeet. Gogebic Lake and in the Bessemer-Ironwood region. Introduced.

Verbascum blattaria L. Moth Mullein. Waste ground northeast of Watersmeet. Introduced.

Linaria linaria (L.) Karst. Butter-and-Eggs. Waste ground, near Watersmeet. Ironwood.

Scrophularia marylandica L. Pilewort. Near Watersmeet. Occasional.

Chelone glabra L. Turtle-head. Low ground, occasional. Near Watersmeet. Gogebic Lake. Probably throughout.

Mimulus ringens L. Monkey-flower. Low, open ground. Frequent.

Mimulus geyeri Torr. Geyer's Monkey-flower. Muddy shores of lakes. Near Watersmeet.

Ilysanthes attenuata (Muhl.) Small. Mud banks. One place at mouth of Eight-Mile Creek, near Gogebic Lake.

Veronica americana Schwein. American Brooklime. Wet soil. Frequent throughout.

Veronica scutellata L. Marsh Speedwell. Shore of Gogebic Lake.

Veronica serpyllifolia L. Thyme-leaved Speedwell. Very common on grassy slopes of the Gogebic Range.

Pedicularis canadensis L. Wood Betony. Sandy soil on the Jack Pine plains.

Melampyrum lineare Lam. Narrow-leaved Cow-wheat. Dry cut-over hills, near Watersmeet.

LENTIBULARIACEAE (BLADDERWORT FAMILY).

Utricularia intermedia Hayne. Flat-leaved Bladderwort. Swampy ground, near Thousand Island Lake. Probably frequent throughout.

PLANTAGINACEAE (PLANTAIN FAMILY).

Plantago major L. Common Plantain. Around settlements. The common species in Gogebic County.

Plantago lanceolata L. Buckthorn Plantain. Waste ground at Bessemer. Introduced. Apparently not common.

RUBIACEAE (MADDER FAMILY).

Mitchella repens L. Partridge-berry. Woods. Occasional. Usually on somewhat dry ground.

Galium triflorum Michx. Sweet-scented Bedstraw. Moist woods. Very common.

Galium trifidum L. Small Bedstraw. Sphagnum bog and wet ground. Frequent.

Galium asprellum Michx. Rough Bedstraw. Moist somewhat open ground, climbing over bushes. Occasional in the lake region.

CAPRIFOLIACEAE (HONEYSUCKLE FAMILY)

Sambucus canadensis L. Black-berried Elder. Near Watersmeet, Gogebic Lake. Apparently not plentiful.

Sambucus racemosa L. Red-berried Elder. Low, shaded ground, near Watersmeet. The common species in the Bessemer-Ironwood region.

Viburnum opulus L. Cranberry-tree. Borders of woods. Frequent throughout.

Triosteum aurantiacum Bicknell. Scarlet-fruited Horse Gentian. Among trees on rocky outcrops at Bessemer.

Linnaea americana Forbes. Twin-flower. Mossy banks in moist woods throughout.

Lonicera glaucescens Rydb. Douglas Honeysuckle. Near Watersmeet. Occasional.

Lonicera canadensis Marsh. American Fly-Honey-suckle. Moist woods, occasional. Throughout.

Diervilla diervilla (L.) MacM. Bush-Honeysuckle. Dry ground. Common after burns. Throughout.

CUCURBITACEAE (GOURD FAMILY).

Micrampelis lobata (Michx.) Greene. Wild Balsam Apple. Low, open ground at Ironwood. Occasional.

CAMPANULACEAE (BELL-FLOWER FAMILY).

Campanula uliginosa Rydb. Blue Marsh Bellflower. In wet ground climbing over other plants. Frequent.

LOBELIACEAE (LOBELIA FAMILY).

Lobelia inflata L. Indian Tobacco. One place near Watersmeet.

CICHORIACEAE (CHICORY FAMILY).

Leontodon taraxacum L. Dandelion Waste ground. Common around settlements. Throughout.

Leontodon erythrospermum (Andrz.) Britton. Red-seeded Dandelion. Roadside near Watersmeet. Also at Bessemer.

Sonchus arvensis L. Corn Sow-thistle. Along C. & N. W. Ry., between State Line and Watersmeet. Introduced.

Sonchus oleraceus L. Annual Sow-thistle. Waste ground. Bessemer. Introduced.

Sonchus asper (L.) Hill Spiny Sow-thistle. Waste ground. Bessemer and Ironwood. Introduced.

Lactuca canadensis L. Tallow Yellow Lettuce. Open ground, near Watersmeet.

Lactuca spicata (Lam) Hitchc Tall Blue Lettuce. Mud Lake. Also near Watersmeet.

Hieracium canadense Michx. Canada Hawkweed. Dry soil, near Watersmeet.

Hieracium scabrum Michx. Rough Hawkweed. Dry soil, near Watersmeet.

Hieracium aurantiacum L Orange Hawkweed. Waste ground at Bessemer and Ironwood. Introduced.

Nabalus albus (L.) Hook Rattlesnake-root. Rich ground, near Watersmeet. Gogebic Lake.

AMBROSIACEAE (RAGWEED FAMILY).

Ambrosia trifida L. Great Ragweed Waste ground. Ironwood.

Ambrosia elatior L. Common Ragweed. Waste ground Ironwood.

Ambrosia psilostachya DC. Western Ragweed. Waste ground along railroad tracks at Ironwood. Also near Watersmeet.

COMPOSITAE (THISTLE FAMILY).

Eupatorium purpureum L. Joe-Pye Weed Moist ground. Throughout.

Eupatorium perfoliatum L. Boneset. Moist ground Occasional, Mamie Lake region.

Eupatorium urticaefolium Reichard White Snake-root Moist woods, near Gogebic Lake.

Grindelia squarrosa (Pursh.) Dunal Broad-leaved Gum-plant Dry ground, near Watersmeet. Coming in from the west and well established.

Solidago flexicaulis L. Broad-leaved Golden-rod. Woods. Gogebic Lake. Bessemer.

Solidago hispida Muhl. Hairy Golden-rod. Dry soil, near Watersmeet.

Solidago uliginosa Nutt. Bog Golden-rod. Boggy ground, common. Near Watersmeet.

Solidago canadensis L Canadian Golden-rod. Dry soil, rather common Watersmeet.

Solidago serotina Ait Late Golden-rod. Moist soil, near Watersmeet.

Solidago nemoralis Ait. Gray Golden-rod. Dry soil. Near Watersmeet.

Euthamia graminifolia (L.) Nutt Flat-topped Golden-rod. Moist soil. Near Watersmeet.

Aster macrophyllus L. Large-leaved Aster. Rather frequent. Rich woods. Frequent throughout.

Aster sagittifolius Willd. Arrow-leaved Aster. Dry soil, near Watersmeet. Occasional.

Aster puniceus L. Purple-stem Aster. Low ground. Frequent throughout.

Aster junceus Ait. Rush Aster. Swampy ground, edge of Mud Lake. Not common.

Aster lateriflorus (L.) Britton. Starved Aster. Moist, shaped ground, near Watersmeet.

Aster tradescanti L. Tradescant's Aster. Low, wet ground, near Watersmeet.

Erigeron ramosus (Walt.) B S P. Daisy Fleabane Along C. & N W. Ry, near Watersmeet.

Leptilon canadense (L.) Britton Horseweed Waste ground. Near Watersmeet. Bessemer. A native weed.

Doellingeria umbellata (Mill.) Nees Flat-top Aster. Moist ground, Mud Lake.

Antennaria neodioica Greene. Smaller Cat's-foot Dry banks, frequent throughout. Common on hills of the Gogebic Range

Anaphalis margaritacea (L) Benth & Hook. Pearly Everlasting. Dry ground Frequent in the lake region. Also at Ironwood and Gogebic Lake.

Gnaphalium decurrens Ives Clammy Everlasting Open ground, near Watersmeet. Occasional.

Gnaphalium uliginosum L. Low Cudweed. Damp soil. Near Watersmeet Occasional

Heliopsis scabra Dunal Rough Ox-eye Dry soil, near Watersmeet Not common. .

Rudbeckia hirta L Black-eyed Susan. Dry ground. Watersmeet Plentiful at one place.

Rudbeckia laciniata L. Tall Cone-flower. Moist ground, near Watersmeet. Frequent in the Bessemer-Ironwood region.

Helianthus divaricatus L. Rough Sunflower. Dry ground, near Watersmeet

Bidens laevis (L.) B.S P. Larger Bur-Marigold. Wet ground. Gogebic Lake

Bidens comosa (A. Gray) Wiegand. Leafty-bracted Tickweed. Common the borders of lakes.

Megalodonta beckii (Torr.) Greene. Water Marigold In shallow water. Occasional. Mamie Lake.

Galinsoga parviflora Cav. Waste ground at Ironwood. One place Introduced.

Helenium autumnale L. Sneezeweed. Banks of the Presque Isle River, near Marenisco

Achillea millefolium L. Yarrow. Waste ground. Bessemer. Near Watersmeet. Gogebic Lake.

Anthemis cotula L. Mayweed. Waste ground. Watersmeet. Bessemer.

Chrysanthemum leucanthemum L. Ox-eye Daisy. Along C. & N. W. Ry, near Watersmeet. Ironwood.

Artemisia biennis Willd. Biennial Wormwood. Waste ground at Watersmeet.

Erechtites hieracifolia (L.) Raf. Fire-weed. Vicinity of Gogebic Lake. A native weed.

Senecio vulgaris L. Common Groundsel. Waste ground. Ironwood. Introduced.

Senecio discoideus (Hook.) Britton. Northern Squaw-weed. Swampy ground. Thousand Island Lake.

Arctium minus Schk. Common Burdock. Waste ground. Near Watersmeet. Bessemer.

Cirsium lanceolatum (L.) Hill Bull-thistle. Bur-thistle. Dry ground, near Watersmeet. Gogebic Lake. Occasional along roads

Cirsium muticum Michx Swamp-thistle. Swampy ground. Bass Lake.

Cirsium arvense (L.) Scop. Canada-thistle. Along C. & N. W. Ry., near Watersmeet. Gogebic Lake. Waste ground, Bessemer. One of the most difficult weeds in the state to eradicate.

Beal Botanical Laboratory, Michigan Agricultural College, East Lansing, Michigan. November, 1920.

NOTES ON THE MICHIGAN FLORA III.

BY OLIVER ATKINS FARWELL.

The great desideratum of Systematic Botany is a stable nomenclature. All students of the science acknowledge this but cannot, or will not, adopt a set of hard and fast rules that will produce the great end desired. Exceptions are the rule of the day and each successive Botanical Congress adds a few more exceptions to the others that have been adopted before A hard and fast set of rules based on priority without exceptions will produce a stable nomenclature, and it never can be had in any other way As the earlier botanists were not troubled with rules and could not see far enough into the future to divine the trouble that such a lack of rules was storing up for those who came after them, they went their indifferent way selecting names that appealed to themselves without regard to uniformity either of terminology or of the derivation of the names adopted and likewise careless of the opinions of others of their own day and generation. Hence to obtain a stable nomenclature botanists of the present day must make a sacrifice of some of their pet hobbies and adopt priority without exceptions as the foundation stone on which to build. If uniformity in terminology is as desirable as stability, it will mean a double adjectival ending for many family names; if such grammatical Bolshevikism cannot be stomached by the purists, then uniformity of terminology and priority of publication cannot be had in so far as family nomenclature is concerned. In this paper grammatical construction will be sacrificed to unformity of terminology, since the latter is considered to be as desirable as stability of nomenclature.

I wish to thank Miss Mary A. Day, Librarian of the Gray Herbarium, for much assistance in matters bibliograpical, and Mr Harold St. Johns of the same institution for identifications of some puzzling material, especially for his identification of *Hymenophysa pubescens*, a long and arduous task. Also I wish to thank Mrs. Chase of the Department of Agriculture for the assistance in determining some grasses as well as for other help.

FLUVIALACEAE Vent. 1799 (Fluviales).

(Potamogetonaceae Dumort 1827).

On July 20, 1919, I observed in Echo Lake (formerly Lakeville) a peculiar Potamogeton that was new to me. It was very plentiful in water under two feet in depth. It did not form a dense growth, but, on the contrary, each stem was sufficiently distant from its neighbor to maintain its distinctive individuality, but close enough so that the aggregated individuals looked like a miniature forest The leaves were prominently two ranked, reminding one very forcibly of *P. epihydrus* Raf. I have been informed by Mr. St. John of the Gray Herbarium that it is *P. strictifolius* Benn. There are some differences, however. The specific name is derived from the

rigidity of the leaves, but this character was not at all noticeable in these plants. The mature leaves are much larger, 4-6 cm. long by 1¼-1½ mm. wide, and the stipules, except on the gemmae, are shorter than the internodes. This species is given a range of from Quebec to E. Mass. and Mich. in Gray's Manual, but it is not recorded in Beal's Michigan Flora unless included in *P. pusillus* L., of which, as suggested in Gray's Manual, it should more properly be considered a variety—*P. pusillus* L. var. *pseudo—rutilus* Benn. No. 5330.

GRAMINACEAE Adans. 1763.

Tripsacum dactyloides Lin. This species is the only native species of the tribe Maydeae to be found in the United States of America. The region of distribution, as given in Gray's Manual, is from Connecticut to Kansas and southward; this would exclude Michigan from its territorial range. Britton and Brown's Manual extends the range somewhat northward and gives from Rhode Island to Nebraska, thence southward; this range would include the southernmost tier of counties in Michigan. The plant has not been officially recorded for Michigan by any of the investigators of the Michigan flora. The species was found by Professor B A. Walpole of Ypsilanti, August 9, 1919, near the Michigan Central tracks west of that city. This extends its range still further northward, as the locality is in the second tier of counties

In the first number of this series of papers (Mich. Acad Sci. 20th Rept. 167, 1918) I gave a list of the species of Panicum that might be looked for in Michigan, among them being *P. microcarpum* Muhl. ex Ell. Since then I have found this species at Detroit (No. 5400½, Oct. 15, 1919). It has been confused with the similar *P. barbulatum* Mx. and has passed under that name, but Hitchcock and Chase recognize it as a distinct species. The latter was also found near Detroit on the same day (No. 5396).

P. Tennesseense Ashe. On sandy hills at Ypsilanti, No. 5236, June 15, 1919.

P Tsugetorum Nash. With the last; No. 5237.

P. umbrosum Le Conte. Near Detroit; No. 5396½, October 15, 1919.

Recently I have had occasion to look up some old collections of Setaria species In trying to determine the names the forms should bear, many obstacles were encountered Mr. F. Tracy Hubbard published in the American Journal of Botany for April, 1915, the results of his extensive studies to determine just what *Setaria Italica*, var. *Germanica* really was; many new names and combinations are presented, but the nomenclature adopted is complicated and is of a polynomial character.

Setaria Italica (Linn.) Beauv. The typical form of the species has yellow fruits on long, compound, interrupted spikes; bristles long and green. This is Hubbard's subspecies *stramineofructa*. (Keweenaw Co., No. 593, Sept. 5, 1887; Belle Isle, No. 593c, Aug. 3, 1894.) The spikes are variable, often reduced in size and length, becoming not interrupted at base; this smaller extreme is the *Panicum Germanicum* of Miller, according to Hubbard, who bases his opinion upon a specimen in Miller's herbarium; this interpretation is different from the ordinary one that the name stands for the forms with purple bristles. The forms with interrupted and non-interrupted spikes intergrade, and plants are often found bearing both

kinds of spikes. If any distinctions are to be recognized it seems better, on the whole, to regard the differences as only of formal rank. As the name *Germanica* is a valid varietal name, Miller's specific name cannot be used for this form; while there may be no law against the use of the same name as a "variety" and as a "form" of the same species, it is better not to so use it in order to avoid unnecessary confusion. It may therefore be known as *Setaria Italica* f. PRAECOX (Alef.) n. f. (*Panicum Italicum* var *praecox* Alef. Landw. Fl. 315, 1866; *S. Italica* var. *Germanica* Hitchc Bail. Cy Am Hort. 4, 1662, 1902; *Setaria Italica* subvar. *Germanica* (Mill) Hubb., l. c 189) Belle Isle No 593d, Aug 3, 1894 The forms with purple bristles constitute the var. *Germanica* (Roth) Schrader, Linnaea 12, 430, 1838. (*Panicum Italicum* var. *Germanicum* (Roth) Koeler, Descr Gram 16, 1802). The typical form usually has an interrupted, rather short spike with bristles from shorter than the spikelet to less than three times as long, that is, under 9 mm in length; *Panicum Germanicum* Roth Tent Fl Germ I. 27, 1788 & II, 71, 1789, as understood here this variety includes *Setaria Italica* subsp *stramineofructa* var *Hostii* subvar *Metzgeri* f. *curtiseta* Hubbard l c. 191. Detroit, Nos. 593a and 593b, Aug. 18, 1893. A variant of this has longer spikes, and bristles over a cm in length; it may be known as *Setaria Italica* var *Germanica* f. METZGERI (Korn) n f (*P Italicum* var *Metzgeri* Korn. Handb. Getreideb. I, 276, 1885) Keweenaw Co, No. 592½, Sept. 5, 1887 This variety, like the specific type, varies with long, interrupted spikes, both forms intergrading; this larger form is the *Panicum Germanicum* Willd Sp. Pl I, 336, 1797 I have not detected it in Michigan, but it may be expected to occur and may be known as *Setaria Italica* var *Germanica* f MACROCHAETA (Korn.) n. f. (*P. Italicum* var. *macrochaetum* Korn [excl. syn] Handb Getreideb. 1, 273, 1885).

Setaria viridis var *major* (Gaud.) Posp A form with large, nodding spikes, interrupted at base; Belle Isle, No 593e, Aug. 3, 1891. Bristles, as in the species, are greenish yellow. Another form with narrower leaves, purplish stems, purplish-green bristles, and with some of the spikelets purplish is *S. viridis* var. *arenosa* Schur; (*S viridis* var. *Weinmanni* [R & S] Brand). Spikes 7 or 8 mm. wide and mostly under 5 cm in length, but a few as long as 7 cm. Detroit, No. 5398½, Oct. 15, 1919. Another form with very narrow leaves, spikes 3 or 4 cm long and 3-6 mm. wide, not at all purplish, but green or yellowish green bristles 6 mm or less long may be considered as belonging to *S. viridis* var *breviseta* (Doll) Hitchc. Belle Isle, No. 629c, Aug. 25, 1895. I have not seen any forms here with bristles as short or shorter than the spikelets, but none were over twice as long.

Sporobolus vaginaeflorus (Torr.) Wood. In sandy soil northwest of Rochester, No. 5390, Sept. 4, 1919. A very large form often 12 dm or more long and spikelets often 6½ mm. long

Sporobolus cryptandrus (Torr.) A. Gray. This species is generally described as with flat leaves and exserted panicle. As it occurs in Michigan it has involute leaves and wholly included panicles and this variant may be known as *Sporobolus cryptandrus* var. INVOLUTUS n. var.; Rochester, No. 5393, Sept. 4, 1919. Torrey described this species as *Agrostis cryptandra* in Ann. Lyc. N. Y. 1 151 (1824). The description calls for a plant with linear flat leaves 2-3 lines broad and a terminal panicle with base only included in its subtending sheath. I have observed the Michigan plant sev-

eral years at different times in the year and I have never seen an exserted panicle or flat leaves; altogether it has a peculiarly rush-like appearance.

Poa trivialis Linn var. *glabra* Doell. Ypsilanti, No 5235, June 15, 1919. Moist banks of the Huron river. According to Gray's Manual the sheaths and blades are retrorsely scabrous in the typical form of the species. In these plants the leaves are rough, but not at all retrorsely so; the culm beneath the panicle and the uppermost sheath are retrorsely scabrous, but below the uppermost sheath the culm and sheaths are essentially smooth. The plants probably are of this variety rather than of the typical form of the species.

Panicularia nervata (Willd.) Kuntze. Willdenow described this species as with a strict panicle, about 6 inches long, with appressed capillary branches and branchlets having green spikelets. This will about cover forms similar to the one mentioned in Gray's Manual as *Glyceria nervata* (Willd.) Trin. var. *stricta* Scribn What is there considered as typical of the species is the var *purpurascens*. A similar form but with spikelets permanently green may be known as *Panicularia nervata* var. VIRIDIS n. var., Ypsilanti, No 5234, June 15, 1919 Probably as common and as widely distributed as the var. *purpurascens*

Bromus hordeaceus L. var. *leptostachyus* (Pers.) Beck. Sterile fields at Ypsilanti; No. 5235½, June 15, 1919 Billington, Farwell and Walpole. The plants previously reported as B. asper Murr. are B purgans L.

CYPERACEAE Adans. 1763.

Stenophyllus capillaris (Linn) Britton. Sandy fields near the Huron River southeast of Ypsilanti; No 5353, Aug. 31, 1919; Billington, Farwell and Walpole. A rare species in Michigan.

Carex cristata Schwein f. ELLIPSOIDALIS n f. Spike shorter than in the species; spikelets aggregated into a dense, ovoid or ellipsoid head. Lakeville, No 5316, July 20, 1919.

Carex sterilis Willd f FLEXIBILIS Farwell. Specimens have been found at Pontiac that had both faces of the perigynia conspicuously nerved with yellowish-brown nerves. No. 5262, June 29, 1919.

Carex cephalophora Muhl. var. BRACTEOSA n. var. A rather lax, woods form, the scales being setaceously long-pointed or awned, the awn much exceeding the perigynia. In the normal form of the species the awns of the scales are short and scarcely noticeable In this form the spikes have a peculiarly bristly or chaffy appearance. Ypsilanti; No. 5283, July 13, 1919; No. 5246, June 14, 1919.

Carex vulpinoidea Michx. var SEGREGATA n. var. Panicle elongated often 4 inches long, all the branches distinctly separated, the lower branches often elongated, and frequently ½ or ¾ inches apart. Dundee, No. 5302, July 15, 1919, and Ypsilanti, No. 5289, July 13, 1919. The type of this species has a rather short panicle, usually under 2½ inches, with the branches closely aggregated into an oblong generally uninterrupted, rarely subinterrupted head; Dundee, No. 5298, July 15, 1919. Var. *setacea* Dewey and var. *scabrior* (Sartw.) Dewey have not been detected in Michigan in so far as I am aware, but a close search might reveal them as the western limits of their ranges includes the eastern part, at least, of the state.

Carex Grayii Carey var. HARIFLORA n. var. Perigynia 2-4 to the head and about 1 cm in length; leaves narrow, about 5 mm. wide. A slender woods form with reduced heads and perigynia. Detroit, No. 5259, June 21, 1919. On July 15, 1919, Mr. Billington and I went to Dundee, Monroe Co, to look for *C. Crus-corvi*, this place being one of the only two stations known in the state for this species; it could not be found. Mr. Billington, however, found it later in the season at Three Oaks. We did, however, find *C. Grayii* var *hispida*; No. 5304. This is not only the first record for Michigan but extends the range of the variety to the northward; the usual range given as of Connecticut to Missouri, passes considerably to the south of Michigan.

JUNCACEAE Vent 1799.

Juncus Greenei Oakes & Tuckern Only four stations are given in Beal's Michigan Flora. Another station for it was discovered July 13, 1919 It was quite plentiful on sand dunes south of Ypsilanti. No. 5274. Billington, Farwell and Walpole.

ARACEAE Adans. 1763

Peltandra Virginica (Linn) Kunth This species is credited to the southern part of the state It probably is not at all common. The typical form seems to be very rare Cass Lake, No. 5228, June 10, 1919. The commoner form has wide spreading basal lobes and is the forma *hastifolia* S. F. Blake. Cass Lake, No 4242, June 29, 1916

LILIACEAE Adans 1763.

Polygonatum canaliculatum var. OBLONGIFOLIUM n. var. This differs from the species in having most of the leaves elongated-oblong to oblong-lanceolate, 3 to 3½ times as long as broad, with the margins of the leaves almost parallel for 2/3 or 3/4 of their length. I would place here my Michigan specimens referred to *P. biflorum* (Walt.) Ell var. *Virginicum*. Bull. Torr. Bot. Club, Vol. 42, 255 and plate 15B. Deam's No. 27801 from Grantsburg, Ind., also belongs here. *P. Virginicum* appears to be a form with rather large leaves derived from *P. biflorum* and will be better understood as a variety of this species than it can be under *P. canaliculatum*, or as Gates has it, under *P commutatum* (R. & S) Dietr. *P. ellipticum* is merely *P. canaliculatum* var. *Americanum* with an elliptical or ancipital stem.

LUPULINACEAE Wulff. 1765.

Humulus Lupulus Linn. An Old World species that has been widely cultivated and has escaped and become naturalized. In the typical form the leaf lobes are coarsely serrate and abruptly toothed at the apex, beneath sparsely resinous with yellow granules; scales of the strobiles obtuse. Detroit, No. 5396a, Oct. 15, 1919. We also have a native form, the variety *Neo-Mexicanus* Nels. & Cockrl. It was first described as *H Americanus* by Nuttall and lastly as *H. Neo-Mexicanus* (Nels. & Cockrl.) Rydberg. It is readily distinguishable from the Old World form by both leaf and strobile characters: the leaf lobes taper gradually to the apex are not at all abruptly

toothed and are more finely serrate and profusely covered underneath with yellow resinous grains; the lowermost scales of the strobiles are acuminate and the upper acute. Banks of the Huron southeast of Ypsilanti, No. 5359, Aug. 31, 1919. Another species of the genus, *H. Japonicus* Sieb. and Zucc., cultivated as an ornamental plant, has escaped and apparently has become established in waste ground. Detroit, No. 5396b, Oct. 15, 1919.

MYRICACEAE Rich. 1808.

Myrica Gale Linn. Mr. Billington found this species at Cass Lake, Oakland Co., in 1916 where it is plentiful. This is far south of the range given in Beal's Michigan Flora, the southern limits as there given is Manistee and Roscommon.

URTICACEAE Endl. 1837.

Urtica Lyallii Wats. Leaves much thinner than in *U. gracilis* Ait. as well as broader and shorter; also with fewer, larger and coarser serratures. Much less frequent Parkedale, No. 4649, Sept. 27, 1917. It has been observed at many other places.

PERSICARIACEAE Adans. 1763.

Polygonum Pensylvanicum var. *laevigatum* Fernald. It appears that the common form of this species in Michigan is this variety. Ypsilanti, No. 5344, Aug. 31, 1919. The typical form with strigose leaves ought to be found in the southern part of the state.

BLITACEAE Adans. 1763.

Kochia scoparia f. trichophila Schinz. and Thell. The typical form of the species remains green throughout the year and the leaves are broader than in this form. I have not seen it. The form with narrow leaves, turning red at fruiting time has been named as above. It has escaped in many places and seems to have become established. River Rouge, No. 4596, Sept. 15, 1917, Goodison; No. 5379, Sept. 4, 1919.

JALAPACEAE Adans. 1763 (Jalapae).

(Nyctaginaceae Lindl.)

Allionia nyctaginea Mx. Rare in Michigan. Ypsilanti, B. A. Walpole, 1918; Farwell, No. 5252, June 15, 1919, and Rochester, No. 5391, Sept. 4, 1919.

Allionia aggregata (Ortega) Spreng. Ypsilanti, B. A. Walpole, 1918; Farwell, No. 5253, June 15, 1919. This is a rather low plant, 3 or 4 dm. high, dichotomously branched, densely viscid hirsute throughout, or the lowest one or two internodes glabrate; leaves ovate-lanceolate, one or two inches long, sparsely hirsute on both sides and more or less ciliate, acute or obtuse, rounded or tapering at the base, short petioled, lowest leaves narrower, involucres single in the axils and a few aggregated at the ends of the branches; pedicels ½ cm. long, slender, pubescent and sparsely hirsute. It has been shown by Dr. Rydberg in Vol. 29, p. 692, Bull. Torr. Bot. Club, that this name has been misapplied by Torrey, Watson and others, and that the real *A. aggregata* is a form of that species more generally known as *A. hirsuta* Pursh, but as this name is of later date than Ortega's the latter's

name must prevail. . The form with the flowers in a terminal panicle, *Allionia hirsuta* Pursh, Fl. Am. Sept. II, 728, 1814, may be known as *Allionia aggregata* var. HIRSUTA (Pursh) n. var

PORTULACACEAE Lindl. 1836.

Portulaca oleracea Linn. var. *sativa* (Haw.) D C (*P. neglecta* Mackenzie and Bush. Detroit, No. 5367, Sept. 3, 1919. A more luxurient form of the species with larger retuse leaves and ascending or erect stems and branches. Introduced from the West Indies.

NYMPHAEACEAE Salisb 1806

In our manuals one of the characters drawn to distinguish *Nymphaea odorata* Dryand from *N. tuberosa* Paine is the purplish under surface of the leaves of the former while in those of the latter they are green. I have observed that in most places in southeastern Michigan, at least, the under-surface of the leaves of *N. tuberosa* are prevailingly purple.

ÇRUCIFERACEAE Adans. 1763.

One of the most remarkable of floral discoveries was made by Mr. B A. Walpole at Ypsilanti. It had all the local botanists, and many who were not, guessing for a long time and unable to place it. Mr. Harold St. John ultimately succeeded in locating it at the Gray Herbarium. The plant is *Hymenophysa pubescens* C. A. Meyer. Bentham and Hooker, f. in their Genera, place it after Lepidium; but Engler and Prantl place it at the end of the family in a list of genera whose relationship is uncertain. The native country is that bordering on the Altai regions or, as Mr. St. John has it, "The Saline deserts of Soongorokirghsici, a region just north of Turkestan"; he says that he can find no record of it either in North America or Europe. It is a far jump from the Altai mountains in China to Ypsilanti, Michigan, and the only way which seems feasible to me is by way of old rags which are gathered up from the ends of the earth and finally find their way to paper mills. The location is close by the Ypsilanti paper mills and it is reasonable to suppose that some of the rags used there came from the Altai region, bringing some of the seed of the plant which through the various processes of cleaning found their way to the rubbish heap and ultimately to a place in the vicinity of the mills suitable for germination. Mr Walpole suggests another way. He says that during the recent war, military supplies from Siberia and Japan, under the immediate supervision of Japanese, frequently passed over the railroads passing through Ypsilanti and that the Japanese were often seen to throw remnants of meals, etc., from the trains He thinks, therefore, that the migration of the seed was in some way connected with the transportation of war supplies. If this is so, we should expect to learn that it has been found at other stations along the route.

Hesperis matronalis Linn var. *albiflora* D.C. Flowers white. Ypsilanti, No. 5233, June 15, 1919.

ROSACEAE Adans. 1763.

Potentilla palustris Linn var. *villosa* (Pers.) Lehm. A form with glandular villous petioles, branches, etc. Near Pontiac, No. 5265, June 29, 1919.

LEGUMINACEAE Adans. 1763.

Cassia Tora Linn. Near the railroad tracks, probably an introduction. Detroit, No. 5402, Oct. 15, 1919.

Psoralea pedunculata (Mill.) Vail. Near the railroad tracks; probably an introduction. Royal Oak, No. 5260; June 24, 1919.

Lespedeza frutescens (Linn) Britton var. ACUTIFRUCTA n. var. Differs from the typical form of the species in the form of the fruit which is elliptical and sharply acute or acuminate, 6-8 mm. long, 2½-3½ wide, that of the species as it occurs here being orbicular to ovate and 3½-5 mm. long. It seems to agree with the *L. acuticarpa* of Mackenzie and Bush in fruit characters, but otherwise it does not differ from the ordinary form of *L frutescens*. Detroit, No 889a, Sept. 24, 1900.

CALCARATACEAE Batsch, 1786 (Calcaratae).

(Violaceae Augier.)

Viola sagittata Alt. var. SUBSAGITTATA (Greene) n. var. (*Viola subsagittata* Greene, Pittonia III, 315, 1898). This is the pubescent form of the species that is quite dwarfed at flowering time, but later in the season it attains much the size of the normal form but does not lose its pubescence. Detroit, No. 5223a, May 1, 1919; Bloomfield Center, No. 4605, Sept. 16, 1917.

VACCINIACEAE Adans 1763.

(Ericaceae Juss.)

Pyrola asarifolia Mx. In rich woods near Rochester, No. 5230, June 13, 1919. Very scarce.

ASCLEPIADACEAE Jacq. 1778.

Acerates viridiflora Ell. var. *lanceolata* (Ives) A. Gray. Sand dunes south of Ypsilanti, No. 5276, July 13, 1919. This variety has not before been reported for the state and is not mentioned in Beal's Michigan Flora.

RINGENTACEAE Rueling, 1774.

(Srophulariaceae Juss. 1789.)

Scrophularia Marilandica Linn var. VIRIDIS n. var. Differs from the typical form of the species in having the corolla and both fertile and sterile stamens green. Ypsilanti, No. 5341, Aug. 31, 1919.

PLANTAGINACEAE Necker, 1770.

Plantago lanceolata Linn. f COMPOSITA n. f. Similar to the typical form of the species, but the spike has several short branches at the base. Fields near Pontiac. No. 5268, June 29, 1919.

COMPOSITACEAE Adans. 1763.

Solidago pulcherrima A. Nels. I include here a plant that is closely allied to *S. memoralis* Ait., but very readily distinguishable in its smaller, denser, thyrsoid inflorescence, the whole plant being much paler and softer-cinereous, and in the oblanceolate leaves, often very narrowly so. It has been reported as *S. mollis* Bartl. on the authority of the late Dr. E. L. Greene. *S. mollis*, however, is said to have acute involucral bracts, while the

involucral bracts of these plants are linear-oblong and obtuse. Detroit, No. 933a, Sept. 27, 1895; Goodison, No. 5381, Sept. 4, 1919.

Rudbeckia triloba Linn. Late in 1918, I found in the vicinity of Detroit a few rather old and dilapidated fruiting plants of, to me, a peculiar aspect which proved upon close examination to be of this species. No. 5216.

Helianthus divaricatus Linn var. TERNATUS n var. Leaves and branches in threes. Near Ypsilanti. No. 5248, June 15, 1919.

Senecio obovatus Muhl. var. MINOR n. var. Low, stem 2 dm. or less in height, portion below the inflorescence 1-3 cm, leafless except for the lanceolate to linear-subulate, entire bracts subtending the floral branches; rosette leaves variable in size and shape, obovate, oval, suborbicular (6-20 mm wide by 11-30 long) and crenate, to lanceolate or narrowly oblong-oblanceolate (6 or 7 cm. long by 15-18 mm. wide) and coarsely toothed, or lanceolate and entire except for the lacinate base Fields and pastures at Ypsilanti No. 5251a, June 15, 1919.

Helenium tenuifolium Nutt. Waste grounds in the manufacturing district. Detroit, No. 5370, Sept. 3, 1919.

Achillea Millefolium Linn var. *rosea* T. & G. I collected this at Ypsilanti in 1891. No. 1162 It grows along roadsides without cultivation and in woods in the near vicinity of the city. I have seen it several times since and it has held its own during the past 30 years without variation. It seems to be worth recognition as a good, stable variety

In the Journal of Botany for April, 1913. Mr. A. H Evans presented a brief on the British species of *Arctium*, giving very complete synonymy. According to his view typical *A. Lappa* Linn is equivalent to *A majus* Bernh., and *A. tomentosum* Mill becomes *A. Lappa* f. *subtomentosum* (Legr) Evans. The typical form of *A. minus* (Hill) Bernh has green stems and light pink flowers. This form is quite scarce in southeastern Michigan, but it was found at Lakeville last summer, growing in dry situations near a fence. Billington, Farwell and Walpole, No. 5311, July 20, 1919 The common form of this species in this section of the state has purple stems and purple flowers and is known as *A. minus* f *purpureum* (Blytt) Evans Another form found at Detroit had purple stems as in f. *purpureum*, but the flowers were white, verging to pale pink, as in the species and may be known as *Arctium minus* f. PALLIDUM n. f. No 5368 (white flowers) and No. 5369 (pale pink flowers), Sept. 3, 1919.

Cirsium undulatum (Nutt.) Spreng. Mr Walpole found this species in June, 1919, along the railroad tracks east of Ypsilanti.

According to the recent monograph of *Xanthium* by Millspaugh and Sherff, the name *X. Canadense* Mill. disappears from the North American flora. The true *X. Canadense* is a European species, the *X. orientale* Linn, a name that is as equally inappropriate, viewed from a geographical point of view. The species that passed under this name (also as *X. glabratum* Britt.) is now said to be the *X. Chinense* Mill Franklin, No. 5154, Sept. 23, 1918; Oakwood, No. 5118, Sept. 15, 1918. Another form is recognized as *X. Pensylvanicum* Wallr. Oakwood, Nos. 5119 and 5120, Sept. 15, 1918, Detroit, No. 5395, Oct. 15, 1919. *X. commune* Britt. and *X. glanduliferum* Greene now *X. Italicum* Mor. River Rouge, No. 5139, Sept 15, 1918; Ypsilanti, No. 5350, Aug. 31, 1919.

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THE RELATION BETWEEN THE COMMON WEEDS OF MICHIGAN AND THOSE FOUND IN COMMERCIAL SEED.[1]

BY BERTHA A. HOLLISTER.

In my work as a seed analyst, I have been interested in comparing the weed-seed content of the samples which I tested in the laboratory with the weeds which are common in the state

As one walks along the roadside or glances over the fields and meadows, certain plants impress one by their great numbers. Are the seeds of these plants the ones which are found as contaminations of commercial seed? If the weed seeds found in commercial seed are not the seeds of the commonest weeds, what causes the difference?

In Professor Darlington's article on the introduction of weeds into the state[2] are listed about 150 weeds, many of which are common throughout the state. Upon comparing this list with the lists which I make in my laboratory each year, I find that they correspond to a considerable extent, so that with the exception of a relatively small number, we can safely say that the majority of the common introduced weeds entered the state as contamination of commercial seed. It is the exceptions that are of interest, as they illustrate several points.

Probably the commonest of all the weeds in the state is the dandelion (*Leontodon taraxacum*). This is rarely found in commercial seed. This is probably due to the fact that the pappus adheres tightly to the achene, so that the slightest fanning cleans it out. Another factor is the length of time through which the seeds are ripening, not all of them maturing at the same time as the cultivated crop.

Canada Thistle (*Cirsium arvense*), on the other hand, is not only all too common as a weed in Michigan, but it frequently occurs in seed. The pappus of the Canada thistle achenes does not adhere tightly and is easily detached, so that only the pappus is fanned out. The seeds ripen at the same time as do many of the cultivated crops and are accordingly harvested with them. *Linaria linaria* (Butter and Eggs) and *Asclepias syriaca* (Common Milkweed) fall in much the same class as Dandelion, in that they are easily fanned out, and so occur very rarely in commercial seed, although they are common weeds in the state.

The seeds most frequently occurring in crop seed include *Ambrosia elatior* (Ragweed), *Plantago lanceolata* (Buckhorn), *Chaetochloa viridis* (Pigeon Grass) *Rumex acetosella* (Sorrel), *Rumex crispus* (Dock), *Persicaria persicaria* (Lady's thumb), *Syntherisma sanguinale* (Crab Grass), *Anthemis cotula* (Dog's fennel), *Chenopodium album* (Lamb's Quarters), *Amaranthus graecizans* (Tumble weed), *Barbarea barbarea* (Yellow Rocket), *Cerastium vulgatum* (Mouse-ear Chickweed), one or two of the Brassicas and *Silene*

[1] Contribution No 67 from Department of Botany, Michigan Agricultural College.

[2] Darlington, H. T. Weed Immigration into Michigan. Mich. Acad. Sci. Rept, 20:261-267, Fig 27, 1918.

noctiflora (Night-flowering Catchfly). These are all common weeds in the state.

Not all of these seeds are found in all of the crop seed, unless the seed is poorly cleaned. Small seeds will screen out of Red Clover or Alfalfa, but will be found in Alsike Clover and Timothy. Large seeds such as *Agrostemma githago* (Corn Cockle) will be found in the small grains and vetches, but are so large that they are screened out of all smaller seed. In the same class as Cockle in respect to size are the seeds of the wild rose (Rosa sp.), which are often found in Oats. There are very few of our weed seeds which do not find their way into some kinds of commercial seeds at one time or another Fortunately for the seed analyst, these do not all occur in the same sample, although I have tested seed which contained half a hundred different kinds of weed seeds.

The weed content of a sample is often of great value in determining the source of the seed. We advocate the use of Michigan-grown seed wherever practicable. If a lot of seed which is offered for sale contains seeds of plants which are not found in Michigan, we know that the seed was grown in another locality. Sometimes we are able to determine the section of the country. As far as we know, *Centaurea picris* (Russian Knapweed) has not produced seed in this country; therefore when we find a sample of Alfalfa containing seeds of this plant, we know that it came from Turkestan. This year a great deal of Red Clover and Alfalfa is being imported from Italy and other European countries These lots of seed contain several kinds of weed seeds which are not found in this country, and one or two others which are found only in restricted localities. By identifying these seeds we are able to detect imported seed in most cases Timothy from Idaho usually contains seeds of *Epilobium paniculatum* (Panicled Willow-Herb), a plant which does not occur in large numbers in other sections of the country. Red Clover grown in the Willamette Valley in Oregon contains many seeds of *Geranium dissectum* (Cut-leaved Crane's-bill), a weed which is only occasional elsewhere.

The information which can be derived from the weed content is of great value to both the farmer and the dealer. By making use of it, seed which is adaptable for their section of the country may be secured.

Michigan Agricultural College

THE ANATOMY OF THE HAUSTORIAL ROOTS OF COMANDRA [1]

BY E. F. WOODCOCK AND R. DE ZEEUW.

The existence of parasitism as a life relation among the higher plants has long been recognized. De Candolle originated and supported for a long time the erroneous conception that all of these parasites may be divided into two clases: Those that live upon the stems of the hosts, and those that live upon the roots. The former were supposed to be green and semi-independent, while the latter were supposed to be entirely dependent on the host and white, yellow or violet in color.

Decaisne (2) proved that the statement made by De Candolle and supported by the weight of his authority did not hold, for in 1847 he established the parasitism of the Rhinanthoideae, in which the parasitism is not the simple sort described by De Candolle Mitten (5), working on the Rhinanthoideae during the same year, brought additional evidence to support the contention of Decaisne.

Further evidence in this direction was supplied by the work of Leclerc du Sablon (4) and Solms Laubach (6). The work of the latter, and especially that of Barber (1), placed great emphasis upon the morphology and development of the hausloria.

This paper is restricted exclusively to the structure of the haustorium of *Comandra pallida* on the roots of the apple. The material was obtained from P S. Darlington, Inspector of Orchards in the Wenatchee District, Washington. A portion of the Comandra stem and also some of its haustorial roots attached to apple roots were sent to the Michigan Agricultural College for identification as to genus and species.

The fact that Darlington found *Comandra pallida* parasitic on apple roots presents the possibility of its becoming a somewhat serious pest in the fruit-growing sections.

An interesting thing that might be mentioned in passing is the clear blue color in the cortical region of the underground stems and roots. The cause of the color is a crystalline deposit associated with the cell walls. The composition of this deposit may have been worked out by some one else, but we are not aware of it. Several strong acids and strong alkalis failed even to change the color when left on the tissue for a long time

The haustorium of *Comandra pallida* appears as a white conical mass, closely attached to the root. The smaller, younger haustoria are hemispherical at first, becoming elongated as the root increases in length. This is true also for Santalum (1), but in contrast to Buckleya (3), in which the elongation takes place at right angles to the long axis of the root attacked. The area of attachment and the scàr left behind by the haustorium are oval. The surface of contact is concave, fitting closely to the bark of the host.

[1] Contribution No. 68 from the Department of Botany, Michigan Agricultural College.

The size of the haustorium varies a great deal, its dimensions being dependent upon its age and also the age of the host root. On some of the older roots they are 5 mm. in length and 3 mm. in width.

The typical conical shape does not always hold for all haustoria. This variation is due to the fact that the soft parenchymatous tissue of which the haustoria are largely constructed responds readily to the pressure of the soil surrounding the roots and the haustoria themselves.

Some of the haustoria appear at the end of the root as well as scattered along its length This apparent "terminal" position is due to the fact that the part of the root beyond the point of attachment to the haustorium becomes atrophied at an early stage of growth. This condition was also pointed out by Kusano (3) in Buckleya and by Barber (1) in Santalum.

Judging from the small size of the roots between the haustoria and the number of haustoria present, it is evident that the most active absorption by the parasite is carried on by the smaller haustoria. Some large haustoria found on old apple tree roots showed evidence of a loss of absorptive power

A careful observation of numerous cross sections of different haustoria gave the following results. The endodermis of the root opens out where the mother root joins the haustorium, and apparently the upper proximal part of the haustorium is formed from tissues inside the endodermal layer.

The body of the haustorium is made up of thin-walled parenchyma cells. At the broad distal end (Plate XV, A) the cells in the central region become somewhat indistinct, densely filled with cytoplasm and actively dividing. On the outside of this central region there appears the cortical region (Plate XV, B).

When the absorptive or distal region of the haustorium comes in contact with the root, there apparently is secreted an enzyme which digests the tissues of the host, the cortical tissues being easily penetrated by the haustorium. When the wood of the host root is encountered, progress is slower As the absorptive region of the haustorium is entering the host, the cortical region proceeds to grow out over the cortex of the host in the form of a fold (Plate XV, C). As growth of the haustorium proceeds, several successive folds may be formed (Plate XV, D).

The function of the later folds differs somewhat from that of the first one formed. The first one is probably merely a clasping fold. The ones formed later are lateral outgrowths of the growing point and push their way between the wood and the cortex of the host, causing the wood to be exposed so that the absorbing part of the haustorium can get at it This becomes very clear when we note the pieces of bark caught between two adjacent folds (Plate XV, F, E). When a new fold is formed beneath the one preceding it, the older one continues to grow along the margin, while it and the bark beneath which it is burrowing are pushed outward. This bark is torn away and imprisoned between this fold and the preceding fold (Plate XV, F). The growth at the margin, causing the fold to grow over the bark beyond the point it had reached at this stage of development, causes it to appear as a clasping organ. This, however, is not the main function of these folds; it is rather to tear away the bark and to expose the wood underneath to the sucking portion of the haustorium. The whole structure takes on the appearance of what Barber (1) called a "compound haustorium." In the middle of each fold is formed sooner or later what

Solms Laubach (6) calls "Trennungs-Streife" (Plate XV, G). How these are formed and what their function is, if any, has not been determined.

The vascular tissue of the haustorium arises in the peripheral tissues of the central region (Plate XV, H), first appearing as a narrow region of elongated cells, which are soon followed by pitted tracheary elements.

Early in the development of the haustorium there is evident a cork layer on the outside, consisting of numerous layers of brick-shaped cells, with somewhat thickened walls. This impervious layer of cells prevents the loss of water from the inner soft parenchyma tissue which makes up the bulk of the haustorium.

There are several factors which operate together in assisting the haustorium to penetrate the host. In the first place, pressure is exerted. This must be the case when we consider that both the haustorium and the root attacked are increasing in bulk while firmly embedded in the soil. Evidence of this pressure is seen in the crushed host cells between the developing sucking region and the surface of contact; in the often altered shape of the attacked root which is sometime flattened; and in the burrowing action of the clasping folds. Careful observation seems to show that the cells of the haustorium have also, as stated above, the power of secreting a ferment capable of dissolving cell walls. The substance secreted has the power of penetrating the host cells for a considerable depth, as is shown by the change in color of the walls of these cells, even before they collapse. This dissolved area is opposite the actively absorbing area of the haustorium.

The results of our investigation on the haustorial roots of Comandra show that De Candolle's classification of parasites into green semi-independent stem parasites and wholly dependent, white, yellow or violet root parasites, does not hold. Decaisne (2), Mitten (5), Leclerc du Sablon (4), Solms Laubach (6) and Barber (1) also arrived at the same conclusion. In *Comandra pallida* we have a root parasite which is semi-independent. The haustorial root, as shown by the plate, apparently acts not only as a clasping organ but also as an absorbing organ. Evidence is seen in the cortical segments imprisoned between the various folds of the haustorium.

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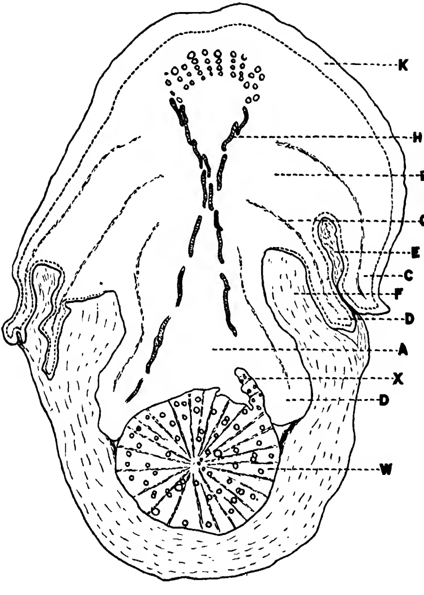
DESCRIPTION OF PLATE XV.

Plate XV Median cross-section through a haustorium of **Comandra pallida** attached to an apple root (x45).

A, central sucking region; **B**, cortical region of haustorium; **C**, first fold formed from cortical region which acts as a clasping organ; **D**, new folds from the cortical region; **E** and **F**, portion of host cortex caught between adjacent folds; **G**, "Trennungs-Streife", **H**, vascular system of haustorium; **K**, cork layer, **W**, wood of host root; **X**, portion of wood partly torn away by the burrowing **haustorium**.

PLATE XV



MORTIERELLA BAINIERI.

BY C. H. KAUFFMAN.

The genus Mortierella has hitherto not been represented in the reported Michigan flora; indeed the members of the Mortierellaceae, the family to which this genus belongs, seems to have had little attention in the United States anywhere. In Europe some 27 species have been described (1). These were found on the dung of various animals; on the fruit-bodies of the higher fungi like Polyporus, Daedalea, Lycoperdon, Agarics, etc.; from the soil in the woods; and in a few cases as facultative parasites; one attacking Mucor, others invading the soil in florists' hothouses and attacking cuttings.

The life history of several species have been studied in culture in great detail. Brefeld (2) investigated *M. Rostafinskii* Bref.; Bachmann (3) studied the physiological reactions of *M. Van Tieghemi* Bach.; and Dauphin (1) did the same with *M. polycephala* Coemens.

Van Tieghem (4) in part with Le Monnier (5) studied and described ten species. Dauphin (l. c.) has compiled all known descriptions and has reproduced the original figures. The zygospores are known for only three of these species, and these are homothallic.

The mycelium of these moulds is mostly horizontal, within the upper layer of the substratum, or weaving a closely adnate weft over its surface. Only the sporangiophores are erect, and these have a tendency to taper almost to a point just below the sporangia, and are more or less swollen or ventricose downwards. No columella is present, and the sporangial wall disappears quickly at maturity, leaving scarcely a remnant at the pointed apex of the sporangiophore. The latter are short, varying from microscopic heights to 1 or 2 mm. in the larger forms, so that they easily escape notice. The zygospores where known, become covered, soon after the formation of the gametes, by a thick layer of closely woven hyphae, which arise from neighboring mycelium, and which mask the process of conjugation and zygospore development, so that it cannot be followed from beginning to end in its external aspects as is possible in Rhizopus, Mucor, etc.

The species I am reporting was collected on a mass of forest leaves which were brought into the laboratory from a piece of woods southwest of Ann Arbor on November 1. This mass of leaves was "mouldy" with a web of luxuriant whitish mycelium, such as some Agarics produce, but which in this case seemed associated with a Clavaria. It was intended to try to develop some fruit-bodies from the mycelium. While examining the material which was kept in a large covered glass dish, minute whitish tufts were noticed on a number of those leaves which were more or less free from the mouldiness of the other fungus. Under a lens, they were seen to be quite distinct erect clusters of some fruiting fungus. Examination under higher magnification showed that they were sporangiophores of a species of Mor-

22d Mich. Acad. Sci. Rept., 1920.

tierella. Transfers were made to beef agar, which happened to be on hand, and it grew luxuriantly, and was evidently free from other fungi. By placing the Petri dish in a cold place, the fungus outgrew the bacteria present, and transfers were made to other media.

On 5% Maltose plus .02% peptone, it grew fairly well, at first immersed, then forming a thin mat, and finally after about a month, a snow-white aerial layer. On pea-broth it also formed eventually this striking snow-white growth over the surface of the liquid. On sucrose-agar it grew slowly, entering the upper layer, and over the surface weaving a very loose but horizontal net of hyphae which bore the sporangiophores, distributed singly, long or quite short, and very different in its habit from that on the leaf-mat from the woods. On removing the lid of the Petri dish, the sporangiophores collapsed after several minutes of exposure, and wherever a mature sporangium touched the other hyphae its evanescent wall disappeared. Also the hyphae of the web had the appearance of coalescing, and this effect was produced where the sporangiophores fell on other hyphae. This phenomenon in species of Mortierella, viz., that the typhae often coalesce where they cross, has been mentioned by others, nevertheless, I could not satisfy myself as to what actually took place, except that in some cases certainly, no true coalescing occurred, but was merely apparent by virtue of the plastic softness of the walls of the hyphae.

On the potato agar the fungus grew much faster, forming spores over the whole dish in four days at a temperature of 20° C, five to six times as rapid as was the growth on sucrose-agar at the same temperature. In two weeks the surface of the potato agar was covered by a thin sheet of woven hyphae mixed with low sporangiophores, and in the course of time this sheet became almost membranous because of its fine and close weave. The color is white, but not so pure as on the liquids mentioned.

The habit of this fungus then is very different on such culture media as have been mentioned, than when it develops on the dead, moist leaves of the forest; for I have no reason to suppose that the conditions in the dish in which the leaves were kept are far different from those outdoors. The temperature was at least as favorable as it must be out of doors. The humidity was controlled to approximate the condition outdoor, and although no Clavaria or agaric fruit-bodies appeared in this dish, I manipulated the cover and controlled evaporation from day to day, just as I did in the case of another dish, in which—as shown in another paper (6)—I twice obtained fruit-bodies of an Agaric.

On its native substratum *Mortierella bainieri* forms a loose creeping mycelium, which may be quite scanty on the surface of the leaves where exposed to evaporation, and from which at scattered points on the leaves, arise tufts of caespitose sporangiophores varying in number from two to a dozen. (Plate XVI, 1.) The mycelium is non-septate and whitish in the actively growing condition, which is also the case during the development of the sporangiophores. Later as these parts become older they become dingy brown, and septa appear in the upper portions of the sporangiophore branches; and the mycelium, especially the old portion within the substratum, may become abundantly septate. The contents of the hyphae is vacuolate in the growing parts, and finally granular with the separation of oil-globules in old portions. The aerial mycelium is usually delicate, rather

uniform in width, and branches freely in a more or less dichotomous manner.

The sporangiophores vary in height from 1 to 1.5 mm., although also shorter. They are abruptly enlarged at the point where they arise from the slender mycelium. The mycelium varies in width from 5-8 microns, while the broadest portions of the sporangiophores have a diameter of 80-100 microns. However, the diameter of both varies with conditions of growth. Below the lateral branches the primary stalk is ventricose or much enlarged, gradually tapering upwards to a slender apex. The sporangiophores from the outdoor material branched variously. As shown in Plate XVI, 2, in the tufts branching occurred only in the upper half, the lateral branches, for the most part, extending considerably beyond the apex of the primary branch, and in this respect, as well as by their racemose origins, differing widely in habit from those of *M. candelabrum* Van Tiegh. and Le Mon. There is a tendency toward the so-called sympodial arrangement, and often only one branch occurs and extends beyond the primary. The branches taper from a swollen lower portion in a manner similar to the main one. Where no definite caespitose tufts arise, single sporangiophores may appear and these usually fork at a short distance above the base of the sporangiophore, without showing any indication of a primary branch. I have never noticed any forking of a lateral branch when development took place in its native habitat, nor in culture. No rhizoids are formed.

The sporangia (Plate XVI, 3, a, b, c) are small, varying 25-35 microns in diameter, with thin transparent, evanescent walls which dissolve in the slightest amount of moisture; there is no columella, so that after the sporangium walls disappears the spores have no support, except that a few may cling to the narrow apex of the branch; small remnants of the sporangial membrane may persist at this apex, but frequently it is entirely denuded. The spores (Plate XVI, 3, d) are short elliptical, 5-7 (8) x 3-4 microns, hyaline, smooth, numerous in sporangium, clearly visible through its membrane and somewhat refractive, the interior without any definite globule, at most with a very minute central particle.

The immersed mycelium in its native substratum was not studied, but in artificial culture solutions chlamydospores (Plate XVI, 5) are formed abundantly. These have the form and appearance of those described and figured for *M. candelabrum* (l. c. pl. 24 Fig. 102). In a culture on pea-broth after three months the dense mat was filled with oval-elliptical chlamydospores which in age become brownish and with a slightly thickened wall (Plate XVI, 5, b). All the mycelium of such an old culture is regularly septate. Such chlamydospores were also found abundant in mats on 0.05% Haemaglobin solution fifty days old. In an old solution of 5% maltose plus 0.2% peptone, the mat contains irregular, closely crowded enlargements, which form a reticulate system with slender irregular connecting hyphae (Plate XVI, 7). This is to be considered a variety of chlamydospore formation or in part a mycelial resting condition. In such cultures, several months old, many small sporangia-like bodies occur, as well as larger ones, produced on short stalks. Some of these have evidently become resting spores, as shown by the definite wall. and easily fall off (Plate XVI, 6). These are the aquatic chlamydospores of Van Tieghem and Le Monnier (l. c. 5. Pl. 24, f. 98 and 106). No stylospores were seen in any of the cultures.

In maltose cultures clusters of globose hyaline spores were observed (Plate XVI, 8, e) whose origin could not be definitely determined; the clusters may reach a large size, 50-80 microns diameter, whose separate cells adhere rather closely and measure 5-7 microns. Their contents is similar to that of the sporangiospores. It is possible that they are the end product of the growth shown in Plate XVI, 8, a, b, c, d, and which was at first assumed to be the beginning of zygospore formation. This development was also observed on beef agar, from which the early stages were drawn. When, however, the clusters mentioned are crushed, there are no bodies indicating any conjugative process, in fact the structures of the clusters remind very much of spore clusters or bulbils in the genus Papulospora (9).

I have referred this species to a form named *Mortierella bainieri* by Constantin (7), the distinguishing characters of which, as briefly given by its author, are the lateral branches of the sporangiophore in their extension beyond the main axis, and the oval spores, which measure "6-9 x 4-5 microns." In these two main points it differs from *M. candelabrum*, as is also shown by his figures. Dauphin (l. c. p. 33) would, however, refer it as a variety of *M. candelabrum*. From all that I can find out about these two species, it seems to me that they are distinct: the spore characters alone are sufficiently specific, and, as I have noted, the habit of the plant is also entirely different. Since Costantin does not give many details, one cannot be quite sure of the identity, but the position of our plant is certainly sufficiently close, and it cannot be referred to any other known species. I would also agree with Constantin that the plant described by Bainer (8) as *M. candelabrum* is to be referred to this species.

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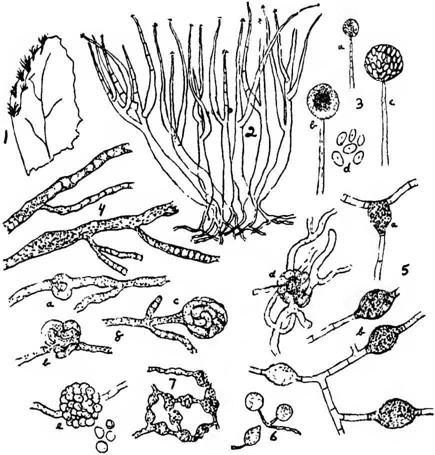
Cryptogamic Laboratory, University of Michigan, March 20, 1920.

PLATE XVI



1. Habit of fungus, nat. size. 2. Tuft of sporangiophores, much enlarged. 3. (a) and (b) young sporangia, (c) mature sporangia, (d) spores. 4. Mycelium from potato agar culture. 5. Chlamydospores of mucoraceous type with wall somewhat thickened. (a) Triangular, (b) elliptical; note three-way branching of mycelium which is frequent. 6. Aquatic chlamydospores. 7. Irregular resting mycelium. 8. Stages in spore-ball formation. (a) Probable initial stage, (b), (c), (d) early stages, (e) ripe spore ball.

A BLACK ROT OF SQUASH

C H KAUFFMAN

Some Hubbard squashes grown near Grass Lake Mich and stored in two different cellars in Ann Arbor last fall developed a dry rot which eventually invaded the whole fleshy part of the squashes Specimens when cut across showed that the invaded portions had turned black and an exami nation of this tissue under the microscope revealed masses of dark brown mycelium throughout the black regions In some cases the whole squash except the rind and the interior was thus changed in color The interior portions had broken down but here the mycelial mouldiness on the seeds and other particles were mostly of a whitish color

Transfers made from the interior of the black tissues yielded a clean culture on agar in Petri dishes and was easily kept growing On synthetic sugar agar containing 02 Peptone growth was good and the culture re mained sterile white or whitish in color whether kept in the dark either at 15 or 20 C or whether exposed during development near a bright lighted window However when transferred from this to corn meal agar either in the light or the dark radiating darker strands of hyphae appeared which became more and more dense and on which after 15 days mature pycnidia had formed scattered singly over the central two thirds of the Petri dish At the end of a month pycnidia were abundant being interpolated among the first ones singly or a few in groups and extending over the whole sur face of the agar The cultures were all repeated with the same result The effect of the light was not striking although pycnidia production seemed somewhat reduced and a thin white flocculent aerial growth had developed which was never present in the dark

The pycnidia are globular slightly depressed or varying at first to sub oval opening by an undifferentiated ostiole 125 300 microns diameter varying greatly in size with a thin membraneous wall which is brown under the microscope and continuous throughout its periphery The cells of the wall are more or less isodiametric one to two layers in thickness The pycnidia are initiated under a thin surface weft of subaerial mycelium breaking through and since the agar becomes soft and watery near the surface they are easily lifted out The pycnidiospores are formed copiously and under proper conditions ooze out in the form of a spore horn or at other times are deposited as a wet mass near the fruit body The spores produced in this way are hyaline short elliptic oblong with rounded ends and measure only 5 6 x 2 5 2 75 microns They are evidently not of normal size and develop ment and were not noticed to germinate although this point has not yet been studied When however a culture on corn meal agar was kept from the beginning at a temperature varying between 4 8° (Sundays at 10°) C although growth was very slow mature pycnidia formed and a consider able number of the spores were found to be 2 celled and larger measuring 6 8 (9) x 3 3 5 (4) microns Furthermore germination of the exuded spores

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was in progress and small windrows of parallel short hyphae were found on all sides of the pycnidia The young mycelium was turning brownish as were the cells of the germinated spore, which had become still larger and somewhat constricted, one cell being often elongated considerably It seems likely that germination of the spores is promoted at the low temperatures

Some Hubbard squashes were then obtained from another source, apparently sound, and later found to have been unaffected by any rot, and one of these was inoculated in two places A square of sterile mycelium, 4 mm diameter, was cut from a young culture of potato agar, and in one case inserted in a shallow opening of the same size in the rind of the squash, in the other case, the square of mycelium culture was fastened to the surface by means of a pin Although the pin naturally produced a means of entrance for the fungus, it was later evident that this was an unnecessary path The squash was then placed in a glass dish and covered After 10 days the inserted mycelium had spread out over the surface of the rind as a thick mat with a horizontal diameter of 5 cm, and that at the pin about 2 cm Cutting across the squash at this time revealed the fact that the blackening had spread laterally in both cases to the periphery of the surface mat of mycelium, and had also invaded the entire thickness of the fleshy portion, spreading out on its inward way The rind was included in the mycelium-infested area

This fungus appears to be *Diplodina citrullina* Grossb, the perithecial stage of which is *Mycosphaerella citrullina* Grossb Grossenbacher's fungus was found capable of attacking the muskmelon, pumpkin and watermelon vines One of the varieties of *Cucurbita maxima* Duchesne, to which the Hubbard squash belongs, was reported resistant in Grossenbacher's paper, including the fruit Massee (2) and Brooks and Price (3) in England have described a tomato and cucumber canker as due to this fungus Grossenbacher had also found the cucumber to be resistant to the parasite The figures and descriptions of the fungus by these workers, and its reaction in culture, leaves no doubt in my mind that the black rot of squash is caused by a species morphologically the same as that studied by the authors mentioned

Cryptogamic Laboratory, University of Michigan, March 22, 1920

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COLLYBIA STRICTIPES, DEVELOPED IN THE LABORATORY

C H KAUFFMAN

On October 15 a mass of forest leaves, which were dug out from a hillside excavation in the Cascade Glen woods near Ann Arbor, were brought into the laboratory A large portion of the matted leaves below the surface of the aggregation, where found, was mouldy with whitish webs of mycelium of some Basidiomycete In fact a few abortive and compressed fruit-bodies of what appeared to be a species of Collybia were found deep in the leaves in the cavity insufficient for their development The mycelium growth extended horizontally several feet through the layers of wet and partially decayed leaf mass, and 5 to 10 inches vertically, being covered by a layer of dryer, loose leaves A number of Agarics have this habit of forming extensive mould-like webs over moist masses of decaying leaves

The mass brought in nearly filled a glass dish 8 5 inches in diameter and 4 5 inches high The dish was placed in a dark room, whose temperature varied only between 15° and 18° C during the following months The mass was thoroughly wet, but sterile water was poured into the side of the dish until it stood about an eighth of an inch deep, but not directly on the leaves themselves, and the dish was then covered with a glass plate After a few days the cover was moved so as to leave a slit on one side for evaporation, which took place very slowly under the conditions in the room The water added at the beginning was not absorbed for at least a month Meanwhile very little extraneous contamination appeared, the surface of the mass retaining its general appearance throughout Of course there was a very slight mouldiness here and there in the bottom of the dish, due to fungus spores already present, but their development never became active, for as soon as such growths became noticeable the lid was moved a little further and more evaporation and aeration resulted Also the temperature did not stimulate these unduly It was rather unexpected to meet with so little trouble from contamination on the surface of the mass of leaves, but here the web of mycelium present from the beginning seemed to exert an inhibitive effect on inroads of ordinary laboratory contaminations This was the more striking, because cultures of a number of species of Mucors and Rhizopus, as well as Imperfecti, were in the same room, and occasionally contaminated stock dishes kept there

On January 15, three months after the culture was started, and without any further addition of water in the meantime, fruit-bodies of *Collybia strictipes* Pk began to appear, and three mature plants were developed in the course of the next two weeks The lid had to be removed and a bell-jar substituted in order to permit of full development These plants were initiated near the bottom of the dish on a newly-developed cushion about an inch in diameter of pure white mycelium, one was formed where a bit of soil was present and the others almost on the glass bottom of the dish.

They reached a height of about 5 inches with strict whitish stem and on critical examination proved to have all the essential characters of *Collybia strictipes* Pk The spores were produced normally and were shed in the usual manner The specimens were removed and water was again added as before In about two weeks another fruit body appeared but since then the cultures have remained sterile

Cryptogamic Laboratory University of Michigan March 1 1920

STUDIES IN PARASITISM I—TOXIC SUBSTANCES PRODUCED BY FUNGI[1]

BY H C YOUNG AND C W BENNETT

Until recently the subject of plant diseases was treated largely from a mycological point of view In their study of the life cycles of fungi, pathologists directed their most effective control measures against the weakest link in the ontogeny of the fungus This method of attack has brought into general usage invaluable control measures and has rendered harmless many formerly serious pests However, there remains a larger group of parasites in which the above method of study has revealed, but little in the matter of control A step further seems necessary and that is to add to the general study of the life cycles, the study of the physiology of the fungus and its physiological relation to its host The problem of chemical changes and the production of toxins within the host has not received the attention that it has in the sister science, animal pathology

The entrance of the fungus into the host tissue has been the subject of numerous investigations and forms one of the important phases of the physiology of parasitism This paper, however, has to do with that phase of parasitism which exists after the fungus has gained entrance into the host An attempt has been made to determine the active factor causing the death of the plant

The immediate cause of death of the plant attacked by a parasitic fungus will depend, of course, upon the species of fungus attacking MacDougal (6), 1911, in an attempted analysis of parasitism thought that exosmosis might be the important factor Later experiments (7), 1917, however, have shown that many hosts have a higher osmotic pressure than the attacking parasites He finally concludes, as does Harris and Lawrence (4), 1916, that osmotic pressure is undoubtedly an important factor in the initiation of parasitism

For a long time the cause of wilts, such as produced by *Fusarium oxysporum* and related organisms, was thought to be due to mechanical clogging of the vascular system This view was orginated by Smith (9), 1899 He states that in the case of watermelons Fusarium, the "fungus is an active parasite and destroys a great many plants by first plugging the water ducts and afterwards invading the parenchymatic tissues" Manns (8) in 1911 holds to this view and states that in connection with Fusarium of potato blight, the fungus readily penetrates the main root, killing the cambium and blocking up the water conducting tubes. This mechanical clogging view has crept quite extensively into the literature

The ground work that really led to the discovery of toxic substances produced by Fusarium wilt organism was laid by Smith (10) in 1904 when he described the discoloration of the actively growing tissues of the host plant. However, it remained for Coons and Goss (3) in 1916 first to demon-

[1] Contribution 69 from Botanical Department of the Michigan Agricultural College

strate that the filtrate from cultures of *Fusarium oxysporum* was as effective as the fungus itself in causing the wilt of potato plants Haskell (5), 1916, working independently discovered the same fact Bisby (1), 1918 also demonstrated the presence of an active principle in filtrates Brandes (2), 1919, states that banana wilt caused by *Fusarium cubense* (E F Smith) is not produced by plugging of the vascular system, but by toxic substances produced by the fungus

This preliminary paper has been confined to a study of the parasitism of *Fusarium oxysporum*, with special emphasis on the toxic substances pro duced

METHODS

A virulent strain of *Fusarium oxysporum* Schl was isolated and used for the experiment Richards' solution, having aPH of 5, was used in all the experiment Three hundred cc of this solution were placed in a 500 cc Ehrlenmeyer flask sterilized and inoculated.

After ten days' time the fungus had produced a heavy mat and the first filtrate was prepared One hundred cc of the fungal extract was pipetted off and filtered The reaction was then determined and the remaining filtrate diluted one to one with distilled water and was placed in vials Freshly cut potato, tomato and celery stems were placed in these vials This operation was repeated every third day until the cultures were 45 days old The following data were obtained

Table Showing Reaction of Media and Wilting Times of Plants (in Hours)

Age of Culture	Ph	Wilting Period Potato	Wilting Period Tomato	Wilting Period Celery	Wilting Period Check Potato
Uninoculated	5	48	42	42	48 hours
10th day	3 8	42	24	----------	48 hours
12th day	4 1	42	24	----------	48 hours
15th day	4 4	42	30	----------	48 hours
20th day	4 8	36	36	8	48 hours
24th day	5 2	36	36	24	48 hours
27th day	5 6	30	32	24	48 hours
30th day	6 2	24	24	20	48 hours
35th day	6 6	12	18	18	48 hours
37th day	6 8	10	12	12	48 hours
40th day	7 4	8	8	12	48 hours

The table reveals some striking data In the culture solution the PH gradually increased toward the acid side until aPH 3 8 was reached Then about the 12th day the reaction turned alkalineward until at the end of 40 days the solution showed a decided alkaline reaction It will be noted that the wilting period for potato decreased as the culture grew older and the solution became less acid In the case of tomato and celery the wilting period was rather short at first but increased up to within the PH range of 5 2 to 5 6, then decreased again as the solution approached alkalinity It would seem therefore that the reaction of the filtrate was in direct proportion with the wilting period Since the solution progressively approached alkalinity, it is clear that regardless of what effect stronger acid solutions have on wilting of plants, in this instance wilting was due neither to organic nor inorganic acids. The wilting was due rather to a compound

of an alkaline nature or to some other toxic product formed when this solution becomes alkaline Plant juices are normally acid, potato and tomato ranging from aPH 4 8 to 5 8 Evidently the wilting period rapidly decreases after the PH of the cell sap is passed by that of the fungus filtrate, thus indicating in this case that if a compound or compounds of alkaline nature are not primarily responsible, they at least accelerate the action of other toxic substances

Further study of the toxic substance was carried on. It was found that autoclaving 15 minutes or boiling 30 minutes did not alter materially the "wilting period" of the filtrate Filtering through Berkfeld filters or diatomaceous earth did not affect the wilting period A test for alkaloids gave a positive reaction, but when the ether soluble alkaloids were separated and brought to the same strength as the original filtrate, the wilting period was greatly increased. The alcoholic precipitate of the filtrate, with reaction and concentration brought to that original filtrate, was effective in causing wilting of potato stems A further isolation is being carried on in this laboratory at the present time

It has been stated that conclusions drawn from the action of fungal filtrates have to be carefully interpreted, as filtrates from a large number of saprophytic fungi will cause potato stems to wilt Bisby (1) states that filtrates from old Rhizopus and Penicillium produced wilting of potato stems more quickly than the extract of Fusarium In our experiments with *Rhizopus nigricans* and species of Penicillium grown in Richards' solution, the filtrate caused decided wilting after the cultures had grown 15 days However, the reaction in the Rhizopus cultures during 6 days' growth changed from PH 5 0 to PH 4 6 and continued to increase in acidity until aPH of 2 2 was reached after about 15 days The acidity in the cultures of Penicillium in the same time reached aPH of 1 8 to 1 0 Any solution as acid as these would cause wilting of almost any plant Moreover, the fact that these fungi cannot invade living tissue renders a comparison with filtrates of parasitic fungi without significance

DISCUSSION AND CONCLUSION

(*a*) The primary and direct factor causing wilt of plants infested with *Fusarium oxysporum* cannot be the clogging of the vascular tubes as has been the general opinion

(*b*) The change in reaction of the culture solution cannot be the primary cause as a reaction of PH 7 4 will not cause potato stems to wilt rapidly Hence the filtrates of old Rhizopus and Penicellium having a decided acid reaction, are not comparable with that of *Fusarium oxysporum*

(*c*) The active factor causing wilt and death of the host plant is a definite chemical compound with a slightly alkaline reaction This compound acts directly upon the active living tissue of the host, probably rendering permeable the selective membrane of the cells

(*d*) Alkaloids, enzymes or toxins have not been eliminated as probable factors Organic acids and aldehydes can hardly be factors

In conclusion we wish to express our thanks to Professor E A Bessey and Dr G H. Coons for helpful suggestions and criticisms

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THE RELATION OF LIGHT TO PYCNIDIUM FORMATION IN THE SPHAEROPSIDALES[1]

G H. COONS AND EZRA LEVIN.

The relation of light to the growth and reproduction of the various groups of fungi has received, as yet, scanty consideration The older authors, as Fries (1), contented themselves with contrasting the type of byssoid growth of certain basidiomycetes found in caves with the sporophores produced from the same fungi under the influence of light It remained for Brefeld (2) to perform definite experiments proving that light possesses definite morphogenic power for certain species of Coprinus Elfving (3), working with Penicillium and similar forms, was led to the conclusion that the effect of light on these forms was comparable to the effect of light on the chlorophyll-bearing plants in inhibiting vegetative growth, and he claimed that light showed fundamental relations to organic syntheses Numerous experiments and observations have been made with certain fungous forms (e g, Pilobolus) in which light serves as directive or stimulative force, but these experiments have rather aimed at the accurate charting of the phenomena than a discovery of the underlying relations

One of us in an investigation of the fungus, *Plenodomus fuscomaculans* (4), found that in this organism light served in a distinctly stimulative or so-called morphogenic way in causing the fungus to produce pycnidia when other conditions were favorable

From an analysis of conditions, it was suggested that light in its effect on the vegetative mycelium of this particular fungus served as an oxydizing force, unlocking the reserves of cellular food, thus furnishing the energy for the fruiting process It was demonstrated that hydrogen peroxide and other oxydizing agents could replace light in pycnidial-formation stimulation within certain limits

The junior author (5), in a preliminary way, tested certain other species of Sphaeropsidales by growing them in test tubes in both light and darkness and found that many forms were favorably influenced in pycnidial production by light

As has been shown elsewhere (4), a fungus demands certain basic conditions for growth, and the conditions permitting fructification have narrower limits than those permitting growth Any experiment which properly tests the effect of light upon an organism must take into account that the organism tested must be grown at suitable temperature, upon a favorable medium for reproduction and with sufficient aeration The ordinary experiment in which organisms growing in test tubes on a rich medium are used,—one series wrapped closely in black paper and another series open, is faulty in that unfavorable conditions for fruit-body formation exist within the test tube and the absorption of heat in the black-wrapped test tube, as well

[1] Contribution 70 from Botanical Department of the Michigan Agricultural College

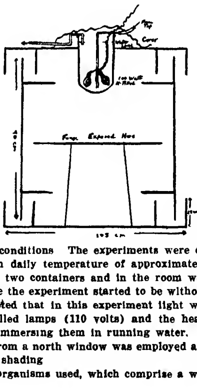
as the scanty aeration, make for entrance of secondary factors too potent to be ignored The test in which two series are used, one exposed to light and the other in a dark chamber, is often faulty through the temperature differences which may exist

The following results were obtained with a larger series of organisms, exposed to conditions of light and dark, under conditions more free from criticism than the test methods for light effects ordinarily employed

In the experiment performed, three conditions—darkness, daylight and electric light—were employed The various organisms named in Table I were grown in test tubes on three kinds of medium—cornmeal agar, oatmeal agar and prune juice agar—made according to standard formulae Eighteen tubes (consisting of six each of the three kinds of substratum) were required for each organism, since the cultures were used in duplicate and each type of medium was tested under the three conditions employed Similar amounts of inoculum were used and the cultures were placed at once under the respective light conditions

The ventilated light and dark chambers were made according to the diagram (Fig 1) of heavy galvanized iron, painted black within and without. One chamber was a ventilated dark chamber similar to the one illustrated, but with no hole in the top The other was equipped with lights as indicated. The cultures were spread out in wheel-shape fashion to give uni-

FIG 1



form exposure and conditions The experiments were conducted in a large basement room with daily temperature of approximately 20° C. The temperature within the two containers and in the room was found by thermograph records before the experiment started to be without marked difference (1°) It will be noted that in this experiment light was furnished by two 100-watt nitrogen filled lamps (110 volts) and the heating of these lights was eliminated by immersing them in running water. In the series in the open, diffuse light from a north window was employed and the cultures were spread out to avoid shading

Nearly all the organisms used, which comprise a wide range of species,

TABLE 1

Pycnidial production in various Sphaeropsidales under the three conditions Diffuse daylight dark electric light

a—light positive b—light indifferent c—light negative ?—Doubtful
C Agar—Cornmeal Agar P J Agar—Prune juice Agar O Agar—Oat Agar

ORGANISM	Behavior	Diffuse daylight						Dark						Electric light					
		C Agar		P J Agar		O Agar		C Agar		P J Agar		O Agar		C Agar		P J Agar		O Agar	
Phoma from Barberry	a	−	−	−	−	+	+	−	−	−	−	−	−	+	−	+	−	+	−
Coniothyrium from Ash	b	+	−	+	+	−	+	−	−	+	+	−	−	+	−	+	+	−	−
Fusicoccum from Lonicera	b	+	+	+	+	+	+	−	−	+	+	+	+	*	+	−	−	+	+
Plenodomus fuscomaculans	a	+	+	+	+	+	+	−	−		−		−	+	−	+	+	+	+
Dothidella quercina	a	−	−	+	−	−	−		−	−	−	−	−	+	+	+	+	+	+
Septoria lycopersici	b	+	+	+	+	+	+	+	+	+		+	+	−	−	−	+	+	+
Hendersonia sp	a	+	+		−	+	+	−	−		−	−	−	−	−	−	−	+	+
Ascochyta viciae	a	−	−	−	−	−	+	−	−	−	−	−	−						−
Phoma sp (yellow spores)	a	−	+		−	+	+	−	−	−	−	−	−	−	−	−	+		+
Fusicoccum celastri	a	−	−	+	+	+		−	−	−	−	−	−	+	−	+	−	−	+
Cytospora ambiens	b	−	−	+		+	+	−	−		+	+	+	−	−	+	−	+	+
Stagonospora from Elymus	?	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−	−	−	−
Coniothyrium from Rose	?	−		−	−	−	−	−	−	−	−	−	−	+	−		−	−	−
Sphaeropsis maclurae	b	+	+	+	+	+	+	−	−		+	+	+	−	−	+	−	+	−
Sphaeropsis sambucina	a	−	−	+	+	+	+	−	−		−	−	−	+	−	−	−	+	−
Phyllosticta from Cow Pea	a	+	−		+	−	−	−	−	−	−	−	−	−	−	−	−	−	−
Sphaeronemella oxyspora	a	+		−	−	+	+	−	−	−	−	−	−	−	−	+	−	−	−
Camarosporium robiniae	a		+	−	+	+	+	−		−	−	−	−	+	−	−	−	−	+
Coniothyrium concentricum	b	+	+	+	+	+	+	+	+	+	+	+	+	−	−	+	−	+	+
Ascochyta pisi	b	+	+	+	+	+	+	+	+	−	−	+	+	+	+	−	−	−	+
Sphaeropsis from Ash	a	+	−	+	+	+	+	−	−	−	−	−	−	−	−	+	−	−	−
Septoria from Phlox	c?	−	−	−	−	−	−	−	−	+	+	−	−	+	−	−	−	−	−
Septoria chrysanthemi	b	+	+	−	−	+	+	+	+	+	+	+	+	(Record lost)					
Dothidella celastri	b	−	−	−		+	+	−	−	−	−	+	+	−	−	−	−	−	−
Septoria pisi	a	+	+	+	+	+	+	−	−	−	−	−	−	+?	−	−	−	−	−
Cytospora carbonacea	a	+	−	−	−	+		−	−	−	−	−	−	−	−	−	−	−	−
Vermicularia sp	b	+	+	+	+	+	+	−	−	+	+	−	−	−	−	−	−	−	−
Coniothyrium from Rhamnus	c?	−	−	−	−	−	−	−	−	−	−	−	−	+	−	−	−	−	−
Diplodia sp	a	+	+	−	−	+	+	−	−	−	−	−	−	−	−	+	+	−	−
Plenodomus lingam	a	−	−	+	+	+	+	−	−	−	−	−	−	+	+	+	−	−	−
Phoma betae	b	+	+			+	+	+	+	+	+	+	+	+	+	+		−	−
Phyllosticta from Lychnis alba	b	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	−	−	−

*Blank spaces represent tubes whose rec rd was lost

were isolated by the junior author from material collected about Ann Arbor, Michigan, and were in every case the outcome of single spore isolations. Where possible, the organisms were identified and are referred to by the appropriate name Others did not correspond with any described species and are referred to the genus only The function of the experiment, however, did not so much concern itself with the attempt to determine *specific* reactions to the light effects, but rather had as the purpose the determination of the *general* behavior of the entire group The test was continued for one and one-half months and the following results obtained

The experiment permits certain conclusions In the first place, it shows that the specificity of the organism must not be lost sight of Because *Plenodomus fuscomaculans* responds remarkably to light stimulus is not evidence that some other species will respond similarly Probably no fundamental of biology is moro often forgotten than this fact, yet every comparative experiment adds similar evidence of the specificity of the organism.

The suggestion that light serves as an oxydizing force may be further considered in the light of these results Here again the specificity of the organism is paramount Even in the dark, certain organisms develop the energy necessary for reproduction when given a certain medium When this medium and the external conditions bring about certain changes in internal conditions, with these organisms perhaps better equipped with oxydizing enzymes, fructification without light readily takes place With others, light is either an essential or great catalytic force, speeding up a process already under way

The organisms tested show in general that the stimulative effect of light upon pycnidial production occurs widely in the various genera of the Sphaeropsidales For such organisms as yielded results sufficient to base a judgment, decision as to the light relation is made From this test it seems evident that under the conditions presented, 16 of the organisms are definitely light positive, yielding fruiting bodies in the light and none in the dark Of these a few gave more uniform pycnidial production in the open than under electric light, but the striking thing of the table is, that so weak a light as would come from two 100-watt, nitrogen-filled incandescent lights, weakened by the approximately two-inch layer of water and the heavy glass container, was sufficient to bring about the reaction The organisms judged as light sensitive are marked "a" in the table Almost as many organisms (12) were found to be indifferent to light, producing pycnidia under all conditions, "b" The behavior of the Septoria from Phlox and possibly one other (Coniothyrium from Rhamnus) would partially indicate a repression action of daylight, "c" There are several organisms in which the behavior was erratic, either the organism not forming fruiting bodies at all under the conditions given, or influenced by the medium or some other condition, not yielding consistent results

The variation in the organism, according to medium, rate of growth, etc, again illustrates the principle urged in a former paper, that certain basic conditions for growth must be satisfied and that the conditions for reproduction are narrower than those for growth.

It is clear, however, that light as a factor in pycnidium formation is significant with numerous species The species of one form-genus do not necessarily behave alike, nor with the few individuals tested is any under-

lying principle for decision as to probable reaction, evident Extensive trial under proper experimental conditions is necessary in any line of work which seeks to bring about reproductive bodies under controlled conditions but in any work the influence of the light factor cannot be disregarded

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METEOROLOGICAL REPORT FOR THE SEASON OF 1919 AT THE UNIVERSITY OF MICHIGAN BIOLOGICAL STATION AT DOUGLAS LAKE

BY FRANK C GATES

The weather of the season of 1919 was of special note because of the establishment of a new minimum temperature viz 35° on the morning of June 29th The seasonal averages were a little below normal The amount of rainfall was abnormally low, being 1 11 inches below seasonal normal and except for 1916, was the lowest recorded Forest fires were frequent and the small movement of wind during July permitted the atmosphere to be oppresively smoky at times

The table below shows the summaries for 1919 the averages of the 8 years of record and the variation of 1919 from this normal (Temperature in degrees Fahrenheit and precipitation in inches)

	July 1919	Average or extreme	Diff	August 1919	Average or extreme	Diff
Absolute maximum	96	104	--------	90	99	----
Average maximum	81 8	80 7	+1 1	76 4	77 4	—1 0
Absolute minimum	38 5	38 5*	--- ----	46	41	-------
Average minimum	55 2	57 4	—2 2	56 3	56 8	—0 5
Mean temperature	66 9	69 1	—2 2	66 4	66 9	—0 5
Precipitation	1 23	1 58	—0 35	2 03	2 64	—0 61
Days of precipitation	6	8	—2	5	7	—2

*The period of data here summarized is from July 1st through August 25th The station was in session from June 30th to August 22d A minimum of 35° occurred on June 29 1919

Manhattan, Kan